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MODERN DRAFTING

BY

J. FRANK MILLER

Modern Drafting

Prepared by

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At present (1911) with The New Jersey Zinc Co- #55-Wall St. New York City

Formerly with The Pennsylvania Steel Co- Carnegie Steel Co- Cambria Steel Co- The American Bridge Co. Milliken Bros- and Architectural and Structural Steel Draftsman in The United States Light-House Service at large.

also

Instructor in Drawing at The Association Institute Y. M. C. A Wilmington Del.

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Draft. Dec, 29, 1911.

Preface

It is not the object of this work to show a pattern or sample of nearly everything. But it is a very valuable guide, or an aid in teaching. When the author began teaching, a great many books and courses in drawing were consulted. Most books were either too elementary or too advanced to suit technical or night school classes. After careful examination they all were discarded and this system devised. It is practical and concise, and has been found, by experience, to be what is needed for trades and night schools.

The work is original and has all been done by the author. The lettering is only fair, but it was considered more valuable to have personal work than to submit the work to a better letterer. The student should not follow the author's lettering, but should practice using sheet #3 as a guide in forming the letters. Some draftsmen make tall slender letters, and others make short fat ones. Use the kind you can make best.

Drafting should not be taught by having drawings copied, but the preliminary work can hardly be covered otherwise. Sheets #3 to #11 inclusive cover the preliminary work, and they should be drawn full size on paper 18"x24" Be sure that each point covered is thoroughly understood, and never permit mere copying. It is a waste of time to draw each of the various "models" in all the different projections. But if the student does not understand the one given, he should draw another model in similar projections in order to clear his mind of the difficult point.

A slight explanation is given for each sheet, but the instructor should watch to see that the student is going about his work in an understanding and draftsman-like manner. Take care to have the top view drawn first, etc.

After sheet #11 is finished the student should be given parts of small machines, or old wooden patterns. He should measure these carefully and draw them to scale. Show all fillets, finish marks etc. If wooden patterns are used the student need make no reductions in measurements but he should understand that the patterns are made larger to allow the metal to shrink to the right size

The sheets following #11 are given as guides. They need not be copied, but are very good examples to follow. The student's first 100 hours should be devoted to the preliminary work, drawing simple parts of machines, making finished drawings of objects shown and dimensioned in isometric, and taking dimensions for views from tables in catalogs etc.

The second 100 hours should be spent in drawing more difficult parts of machines, making free hand dimensioned sketches from machines, draw the parts to scale and make an assembled drawing of the machine, ink in drawings, and trace

This work should be followed by a course in machine design.

Geometrical drawing has been omitted so as not to tire the student before he can have a chance to "Do something worth while." If any problem in geometrical drawing arises the instructor should explain it

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Instruments and Materials.

Drawing Board. Any style or size will do so long as it is larger than the paper, and has a perfectly straight edge. The top should be smooth and free from knots, and of some soft wood. The straight edge of the board must be smooth and perfectly straight if accurate work is to be done. This edge must be at the left. The best boards have a piece of hard wood set in to form this edge.

"T" Square. The "T" Square, so called from its shape, is generally made of wood. One part called the "Head" is held tight to the straight edge of the board in such a manner that the long thin part, called the "Blade" will lie across the board. The blade must be fastened securely to the head, and be long enough to reach across the paper. The head is moved up and down the left edge of the board with the left hand, while the right hand holds the pencil and draws the lines along the upper edge of the blade. The "T" Square is never moved with the right hand, and lines are always drawn from left to right. Only horizontal lines can be drawn with the "T" Square.

Drawing Paper. There are many kinds and colors, but the best paper for ordinary use is a sort of tough "Manilla" paper that takes ink and will stand erasing. Get a sheet of paper a little larger than is needed so that it can be trimmed when finished. Lay the paper on the board as shown on Sheet #1, and take a small large-headed tack, called a "thumb tack;" and push it through the paper into the drawing board. Smooth out the paper and put in a tack in the diagonally opposite corner after stretching the paper as much as it will stand. Put in tacks in the other corners and your paper is ready for use.

Thumb Tacks.

Instruments and Materials.

Triangles. These should be of transparent celluloid. Two triangles are needed. One should be about 8" long and have angles of 45° 45° + 90° The other should be about 10" long and have angles of 30° - 60° + 90° These angles and others made by combining both triangles are shown on sheet #2 All lines except horizontal lines, are drawn along the triangle while it is held against the "T" Square. The pencil is moved in the direction shown by the arrows on Sheet #1

Pencils. Drawing pencils are harder than ordinary pencils, and are marked 1H, 2H, 3H, 4H, 5H, 6H, 7H, or 8H according to the degree of hardness; 8H being the hardest. They should be hexagonal so as not to roll off the board. A 3 or 4H is best for lettering, and a 7 or 8H for drawing. Sharpen them at the opposite end to the mark, then you always have the mark to tell what pencil it is. Keep about $\frac{1}{4}$" to $\frac{3}{8}$" of graphite showing Sharpen the lettering pencil in the ordinary manner, but sharpen the drawing pencil so that it has a flat point like a carpenter's chisel. This is done by rubbing it on a file or sand-paper. Keep the flat side against the T Square or triangle, and always pull or draw the pencil. Never push it point first.

Instruments. A case of drawing instruments with the various names is shown on Sheet #2 Get the best instruments you can afford. Use the smaller instruments whenever possible. In using the large compass, bend the legs so as to keep them perpendicular to the paper. See that both pencil and needle, or pen and needle points are the same length. The needle point is the sharp point which remains fixed while the other point holds pencil or ink.
The other instruments will be discussed later as they are brought into use.

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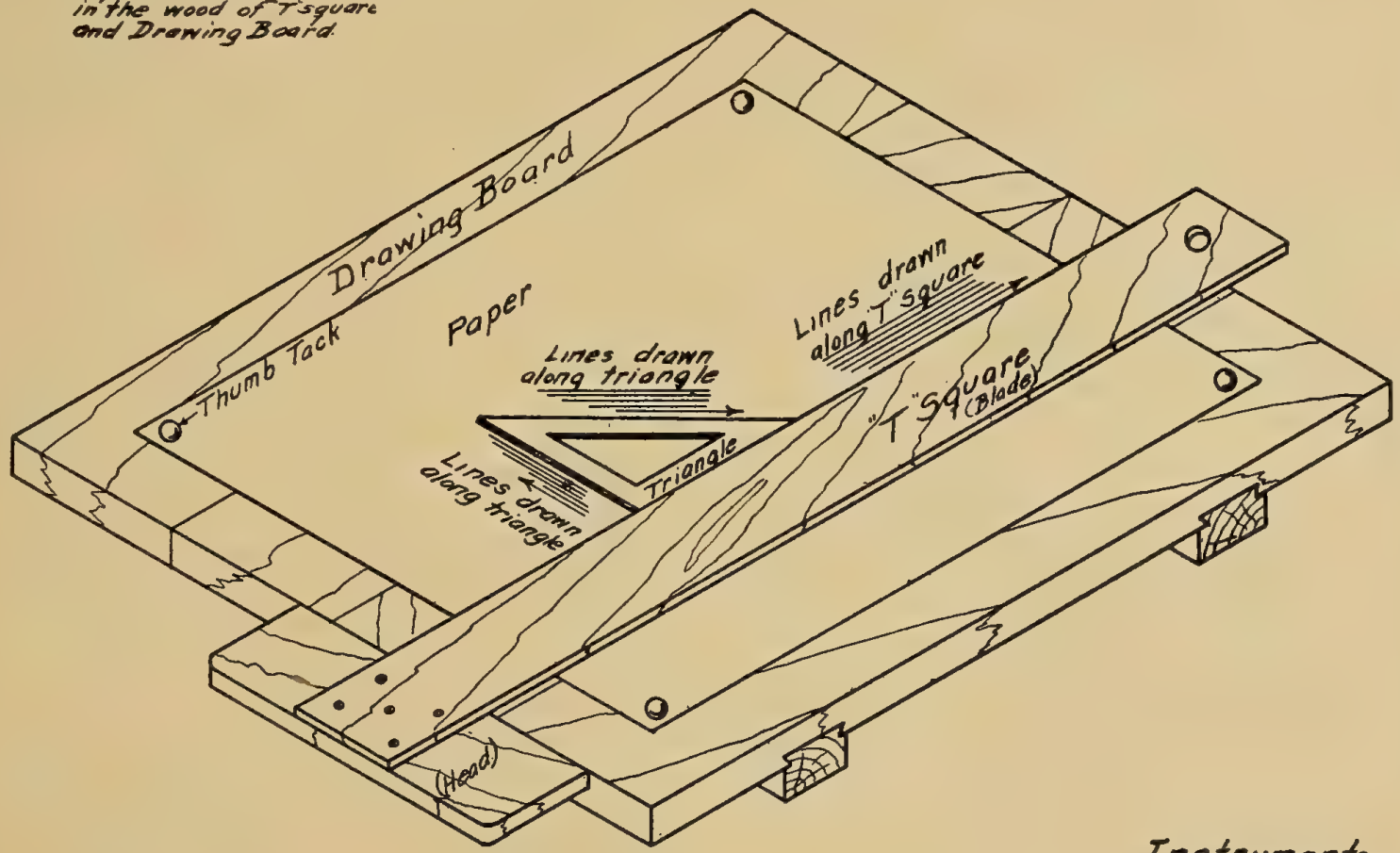
The irregular lines represent the "grain" in the wood of T square and Drawing Board



Instruments

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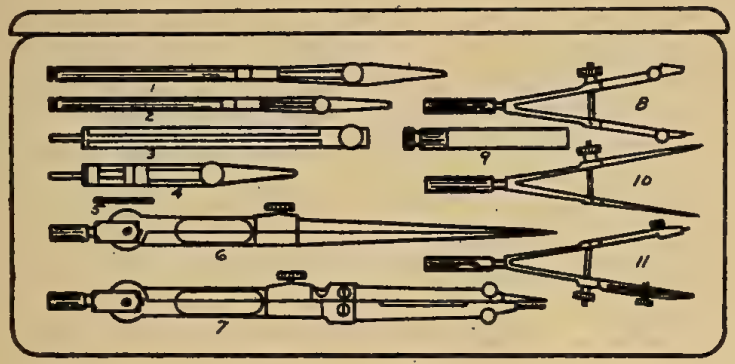
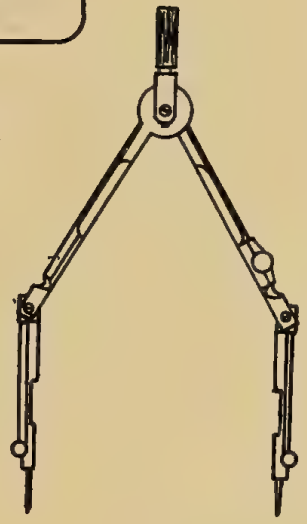
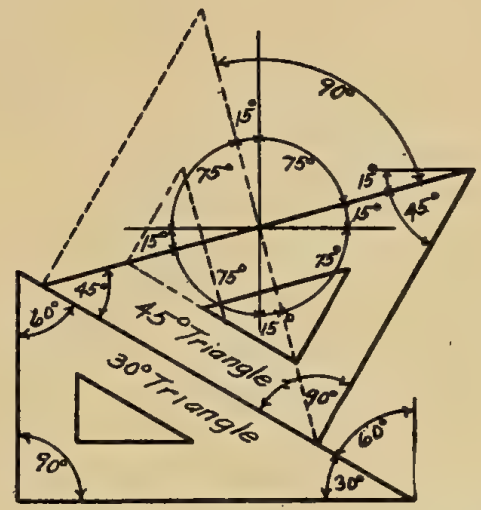


List of Drawing Instruments in the case shown above

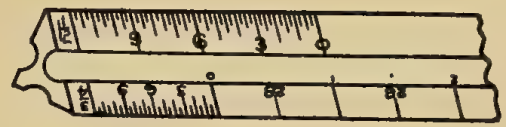
1- Large straight line pen
2- Small " " "
3- Lengthening bar for compass
4- Pen point for compass
5- Key
6- Large dividers
7- Compass
8- Bow Pencil
9- Box for points
10- Small dividers
11- Bow Pen



Compass (legs bent for use)

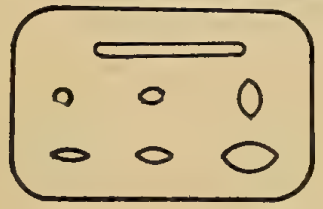


Combinations of Triangles



End of Scale

Irregular Curve



Erasing Shield

Instruments
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Directions for Drawing Sheet #3

These drawings are all made at a scale of 6" to one foot. In other words-"half size" The beginner should work full size until he becomes familiar with drafting. To draw the following sheets, use paper 18"x24" Tack it to the board and draw the heavy border line allowing 1" margin all around except the left, which should be 2" Next divide the sheet inside the border into 4" squares as shown by the light lines. Inside each of these squares draw a heavier square allowing ¼" between it and the light lines. These inside squares should be 3½" on each side Begin with the top row and fill each square with the figures shown Draw the lines ¼" apart. Where the lines are diagonal, measure the ¼" spaces on a light diagonal line running the opposite way. Leave the lettering until last.

In measuring off these distances use the scale just as you would use a ruler, rule, or tape. As you are working full size, use the edge of the scale which is divided into 12 inches and sixteenths. Never draw along the scale. Lay it on the paper and make small dots the distance apart that is required, and then draw the line using the T Square or Triangle Be very careful in pointing off dimensions as they must be exactly right.

Where circles meet straight lines, always draw the circle first: because it is easier to make a line meet a circle than otherwise. In the lower figures draw the light diagonal lines first. The second figure in the bottom row is made by drawing parts of small circles where the lines meet. One circle is shown on the drawing.

Practice lettering in spare moments, and use the system shown. Always draw the guide lines in pencil and after the work is inked in erase the lines. Make each letter carefully and keep all letters in the same slope. Be careful in spacing letters and words. Use all down strokes of the pen Any pen will do. Some use stub pens and others use fine pointed pens.

Try to give the sheets a nice even appearance. Don't crowd the work and take plenty of time.

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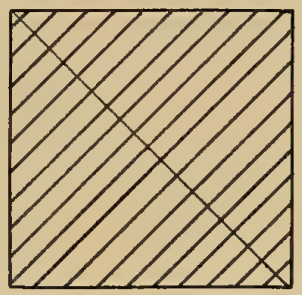
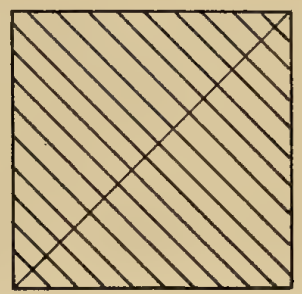
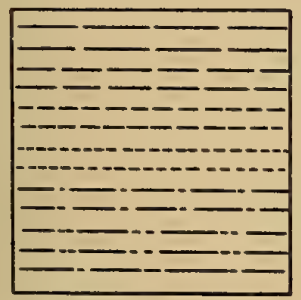
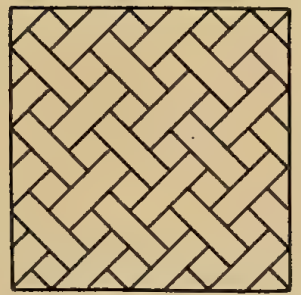
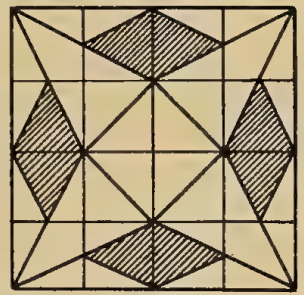
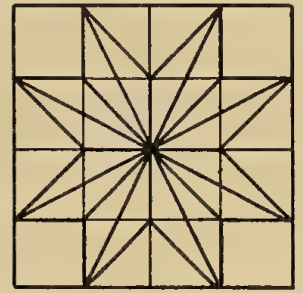
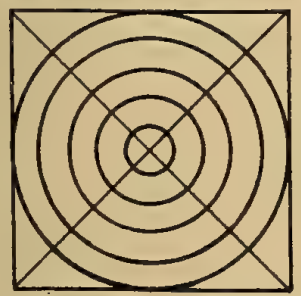
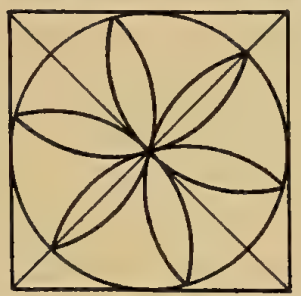
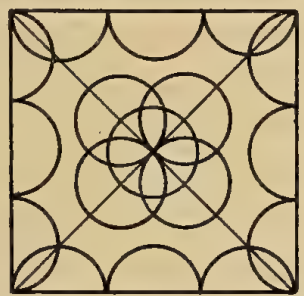
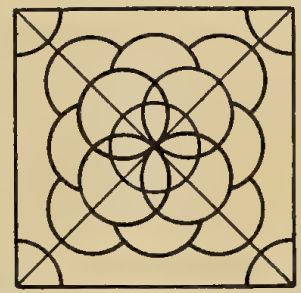

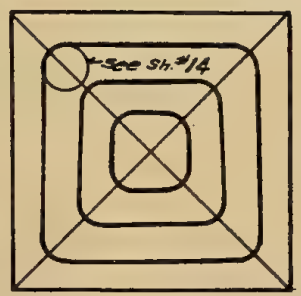

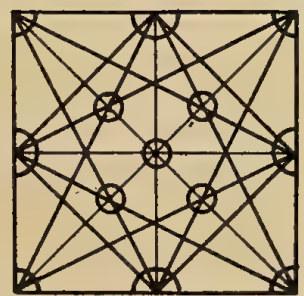
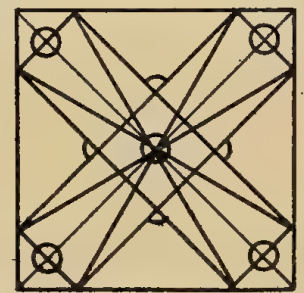

Lettering

There are many styles of letters in use, but the best and most simple is as follows. Each letter is separated into the different parts that compose it. The arrow heads show the direction of the stroke of the pen. (a c t)(b t 3)(c)(d c t)(e e →)(f f →)(g c t)(h t →)(i)(j)(K t ↘)(l)(m t → →)(n t →)(o)(p t 3)(q c t ←)(r t →)(S)(t t →)(U c t)(V ↘ ↗)(W ↘ ↗ ↘ ↗)(X ↘ ↗)(Y ↘ ↗)(Z → ↙ →)(& ° o c)(A t ↗)(B t 3)(C)(D t 3)(E t ⇉)(F t ⇉)(G C →)(H t → t)(I t ⇉)(J J →)(K t ⇉)(L t →)(M t ↘ ↗)(N t ↘ t)(O)(P t 3)(Q O t)(R t ?)(S)(T ⇉)(U)(V ↘ ↗)(W ↘ ↗ ↘ ↗)(X)(Y ↘ ↗)(Z → ↙ →)

Draw guide lines and make the letters come just to the lines. Erase lines after lettering is finished. 1 2 3 4 5 6 7 8

Practice in Use of Instruments

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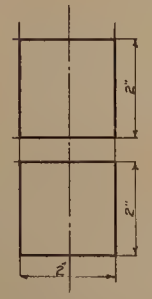
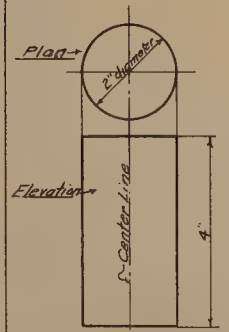
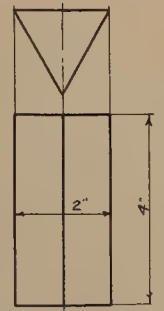
Sheet #4



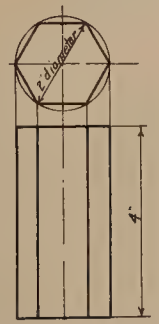
Cube



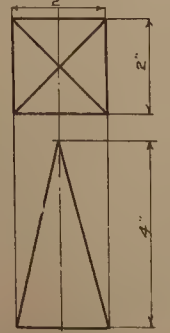
Cylinder



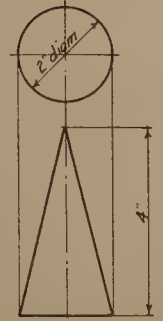
Triangular Prism



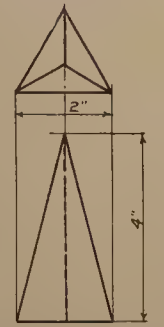
Hexagonal Prism



Square Pyramid



Cone



Triangular Pyramid

Sphere

Scale-6"=1'-0"

Projection-2-Views

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Page #4

Directions for Drawing Sheet #4

A view of an object is a drawing showing its size and shape. Very few objects can be clearly shown in one view. Enough views must be shown to give the complete shape and size so that a mechanic could make the object from the drawing alone, without verbal instructions.

Projection means throwing out or drawing one view from another. We draw the chief view, which is generally the top view or plan; and project the other views from it. The models which are drawn on Sheet #4 get their names from their general shape. Thus if the base of a prism is a hexagon we call the model a hexagonal prism.

Draw border lines as before and draw the light lines dividing the sheet as shown. Always draw the center lines first. Draw dimension lines and put the figures on with arrow heads to show where the dimension goes. All figures and lettering must be put on so that it can be read from the lower right hand corner of the sheet. Some times dimension and construction lines are made dotted. This takes longer and as all lines that you can't see are shown dotted, it is better to draw as shown.

Do not try to get points for all the corners with the scale. In drawing the "Cube" lay the scale on the center line and make two points 2 inches apart. Then leave about ½ inch and make two more 2 inches apart. Draw a line through each of these 4 points using the T Square. Now lay the scale on one of these lines and make a point one inch on each side of the center line. Draw vertical lines through these points using a triangle on the T Square. Finish each model before starting another. Draw the top view or plan first. The triangles and hexagon are drawn with the T Square and 30° triangle. On the elevation of the Triangular Pyramid the back edge can't be seen, but we know it is there so we draw it as a dotted line. Be sure you have all the dimensions given. Make the sheet as pleasing in appearance as possible.

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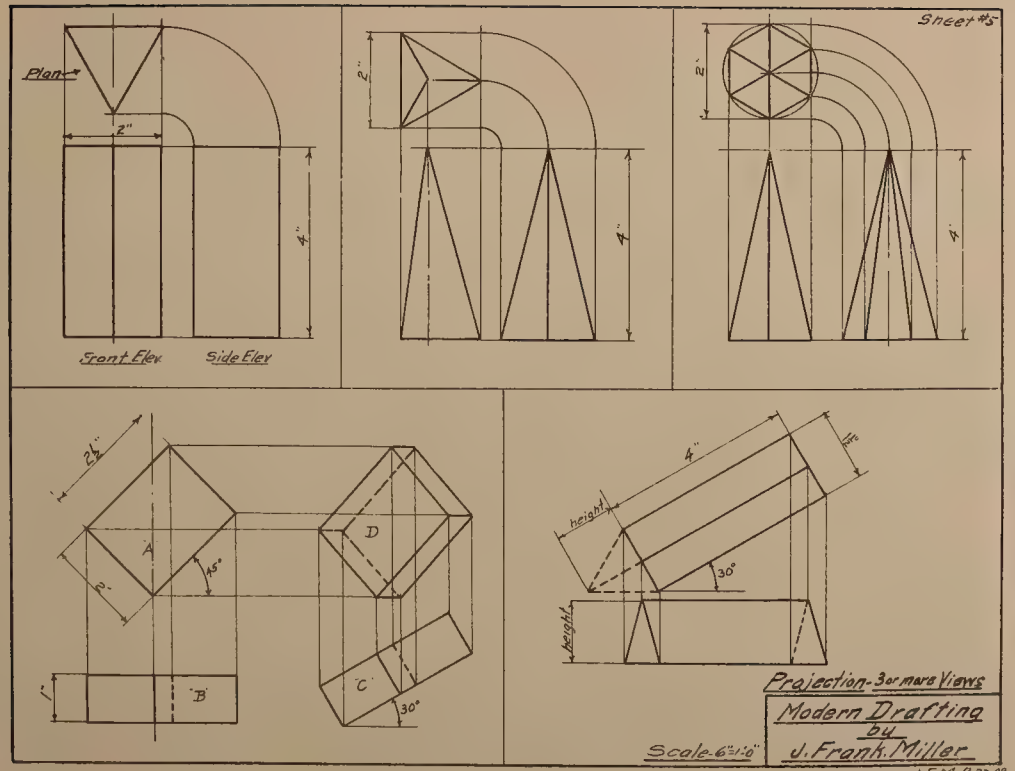

Directions for Drawing Sheet #5

Divide the sheet for the five figures and draw the vertical center lines. The upper part of the sheet contains Front-Top-& Right-side Views of a Triangular Prism, Triangular Pyramid, and Hexagonal Pyramid. Draw the Top View or Plan first. Then project down for the front elevation in the same manner as for Sheet #4 We could calculate the various widths for the side elevation, but it is often difficult. A shorter and easier method is to project all points in the plan to the right until they meet a vertical line through the extreme right hand point in plan or elevation. Project a line through the extreme top point of the elevation, over until it meets the vertical line, and using the meeting point as a center take your compass and draw quadrants of circles through all points made by projecting lines to the right. Draw down from these quadrants until the base line is reached and you have the various widths for the side elevation. Take care to make all straight and curved lines meet exactly. Do not make too large a hole with the needle point on the compass. Press it into the paper only far enough to keep it from slipping.

Draw a plan and elevation of a block 2"x2½"x1" turned at 45° and raised at 30°. This problem takes a slightly different treatment. Draw the plan turned at 45° as shown at "A" Then draw the elevation as at "B" Now we must draw the elevation as at "C" Both elevations are exactly alike except that "C" is raised at 30° Draw "C" with the 30° Triangle using the dividers to transfer dimensions. In using the dividers place one point on a point you wish to transfer, and the other on another point. Now be careful not to move the legs together and prick small holes on the new view to correspond with the old. When "C" is finished project up from each point until you meet a line projected over from a similar point in "A" Connect these intersections and you have the required Plan "D" and Elevation "C" The last problem explains itself. The only point to watch is the "height" of the elevation which is found by drawing an end view of the plan and transfering.

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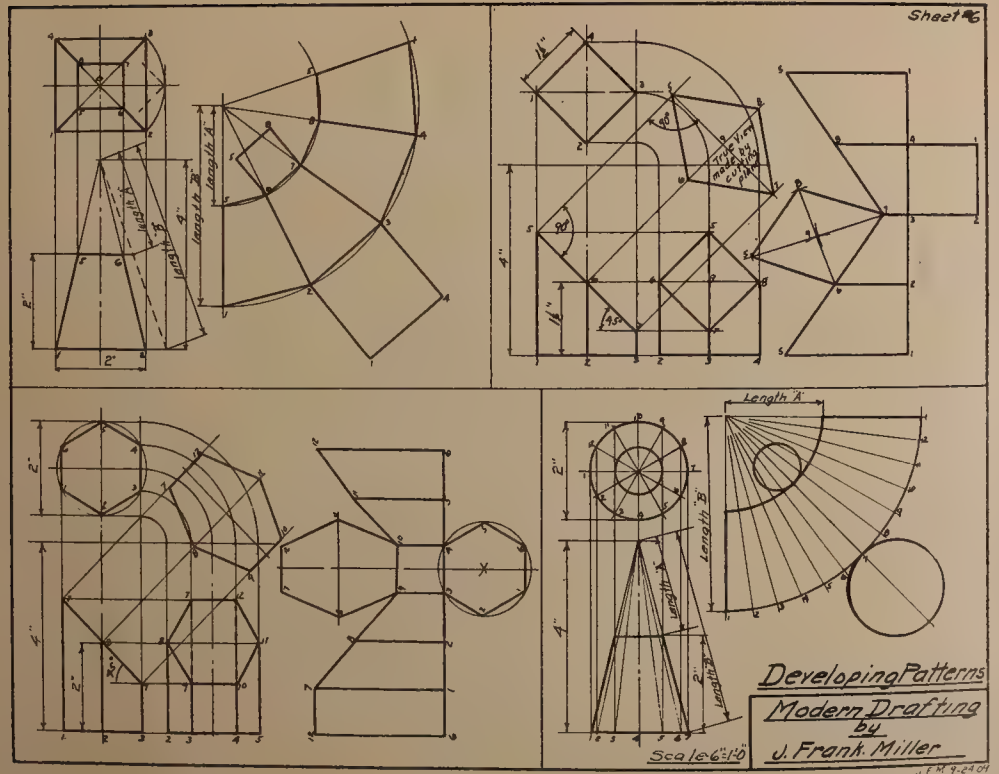

Page #6

Directions for Drawing Sheet #6

Develop the pattern for a 2" square pyramid 4" high cut off horizontally 2" above the base. Draw the plan and elevation as shown on Sheet #4 Then measure up 2" on the center line and draw a horizontal line as shown. Now we want to get a pattern which if cut out and folded together will make a paper model of the pyramid after it is cut off. The pyramid is drawn face toward us, and we must find the greatest length of paper required for the pattern. The greatest length is down the corner, and our elevation does not give this length unless a corner is to the right. Instead of redrawing the figure we take the compass and use 6 as a center draw the arc from 3 to 2 and dot in the corner as shown. Draw all construction lines light and lines which represent the object heavy. Now project down from the dotted corner to the base line and draw the dotted line to the apex of the pyramid. This dotted line is the true length of the corner. Use this length "B" as a radius and draw a segment of a circle. Take the dividers and set off distances 1-2-3-4-1 equal to the same distances on the plan. Connect these points with the point used as a center. Draw an arc with a radius "A". Connect all points and draw the squares 5-6-7-8 and 1-2-3-4. All intersections are given a small figure so that the drawing can be understood by the student, and should not be put on the final drawing

The pattern for a square prism, corner toward you, cut at 45° is made in a similar manner. Draw the plan, elevations, and the true view of the surface made by the cutting plane. The pattern should be easy as it is made by using the dividers to step off the distances obtained from the other views. The lengths 1-2-3-4-1 are taken from the plan

The hexagonal prism is drawn the same as the square prism. The cone and all pyramids must be drawn to a radius. Draw the plan and elevation of the cone. Divide the plan into an even number of parts. We generally use 12 because we can use the 30° triangle to divide the circle. Now draw the arcs and step off 13 points using the distance between each point as found in the plan We use 13 points because when folded the 13th. point coincides with the first.

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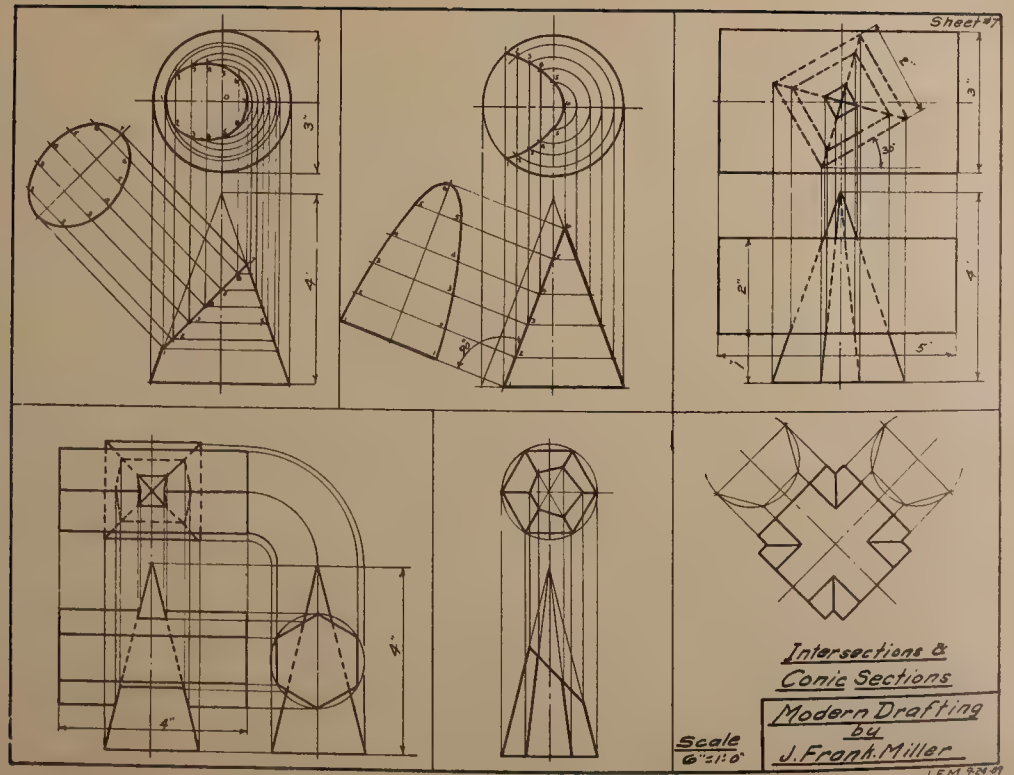
by
J. Frank. Miller

J.F.M. 10-12-04



Page #7

Directions for Drawing Sheet #7

The first two drawings are called Conic Sections Draw the plan and elevation of the cone Then draw the line cutting the cone Divide this line into any number of spaces as at 1-2-3-4 etc having one point about the center of the line Draw horizontal lines through each point and where each of the lines strikes the right hand line of the cone, erect a vertical line to the center line of the plan. With o as a center draw arcs through each of the intersections of the vertical lines and the center line Erect the vertical lines from the points, 1-2-3-etc. in the elevation. Now as you draw the arcs just mentioned use "o" as the center for all of them. Each time you change your radius one point to the right draw the arc until it meets the line one point farther to the left Point 1 has no arc. It is found where the vertical line meets the center line. You should be able to follow each set of lines in this manner. Take point "3 in plan and go down the vertical line to 3 in elevation, cross to "x" then up to "x" in plan. Now use "o" as a center and draw through "x" to the points "3" and "3" This gives us a series of points 1-2-3 etc. in plan We must draw a curve through them and as it will not be a circle we use the irregular curve Lay it on the points and move it around until some part of it will touch 3 consecutive points Draw a curve through them and move the curve around until it touches two points just used and the next one. Draw this in and continue being careful to make the curve smooth The true view made by the cutting plane is made with the curve The distance from the points to the center line is the same as in the plan. Transfer them with the dividers.

The next two are intersections. Draw the square pyramid and then the rectangular block it intersects Where the corners of the pyramid enter and leave the block gives the points for the inner squares in plan. In the next figure draw the right side view first Project up and over for the other views. A study of the views will make it all clear without any further directions.

The other two drawings are easily understood.

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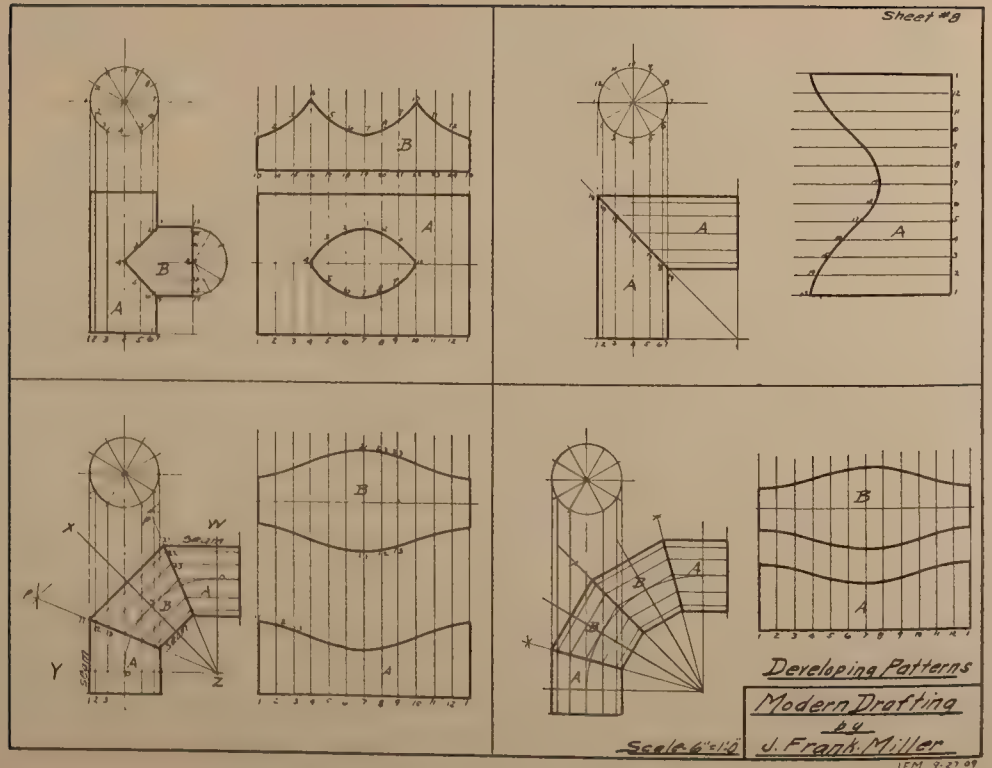
J. Frank. Miller.

J F M 1909



Page #8

Directions for Drawing Sheet #8

This sheet contains the patterns for pipe and elbows Draw the circle for the plan and divide it as shown. Then draw the elevation and the light lines as shown Develope the pattern by drawing a horizontal or vertical line and step off 13 spaces 1-2-3-4-etc the same distance apart as they are on the circle. Then, in the first problem, mark off the distance from 4 to 4 etc by using the dividers and transfering from the elevation. Connect the points thus made by using the irregular curve. The letters A B etc show which piece the developed pattern represents. The only problem in the other three elbows is in dividing the angles in the elevation. Take the three piece elbow First draw a right angle as WZY. The elbow has three pieces and each piece must have a center line. To get these center lines we must bisect the angle WZY Use Z as a center and draw the quadrant of a circle as shown The line X Z may be drawn by using the 45° triangle. Now we have the three center lines and we must bisect the angles between them in order to get the lines through the joints of the various pieces Use the various points marked "o" as centers and with any radius draw arcs intersecting at P Draw the lines PZ and the angle is bisected. The balance of the work is similar to previous work.

In the 4 piece elbow we trisect the right angle to get the four center lines. Do this with the 30° triangle. Now we have three angles to bisect to get the lines through the joints of the various pieces Be careful to get good accurate work. Get the points just right and the curves smooth.

Generally the pieces adjoining have their seams or joints on opposite sides. A would be cut on the outside, B on the inside and so on. This method does not make so many thicknesses where the joints come.

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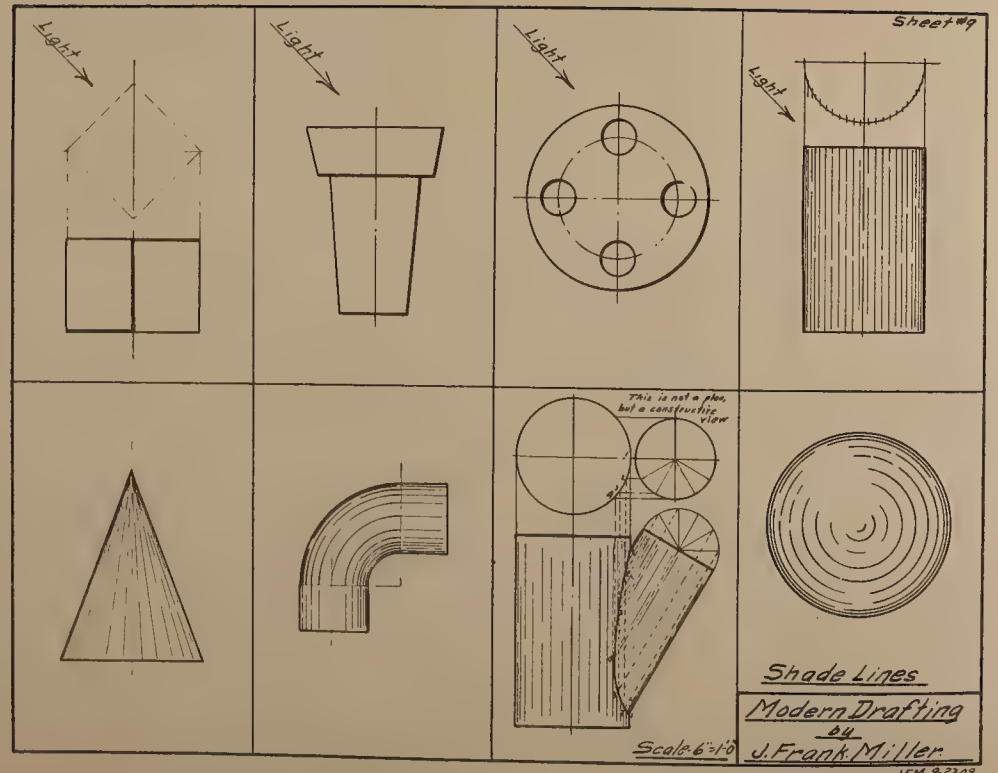


Sheets #9-#10 & #11 are purely theory and any size may be used. They are very simple if once thoroughly understood, and are often very valuable aids to drawing.

Directions for drawing Sheet #9

Two systems of shading are in general use. Both are very simple. The light is supposed to be over the left shoulder, and at an angle of 45° to the paper. The draftsman draws all objects as though the light came as shown by the arrows. This arrangement puts some of the faces in light and some in shadow. Where a light surface meets a shaded one, we draw the line between as a heavy shade line. This line should be of least twice as heavy as an ordinary line. Some times this rule is stated thus:- "Draw all right hand and bottom lines as shade lines." Notice the holes in the disk. The shading is reversed in the holes.

The second method is used mainly to show curved or rounded surfaces. The cylinder has half the plan divided evenly and a shade line run through each point. This shows why the lines are closer together at the sides than in the middle. In practice we never divide the plan, but put the lines in trying to get the best appearance.

Directions for drawing Sheet #10

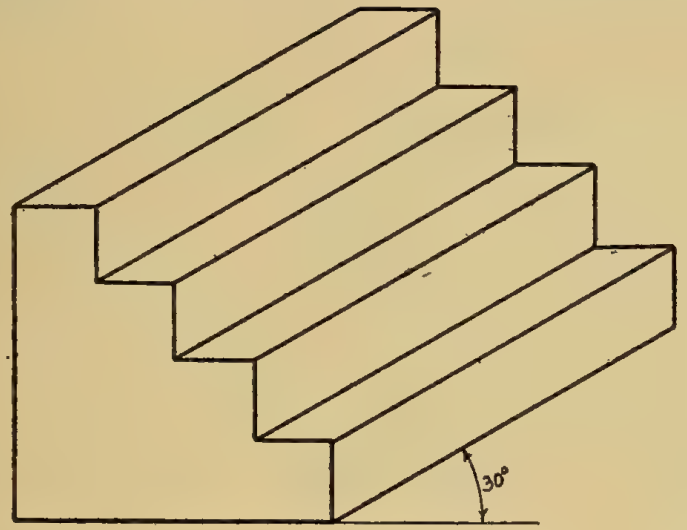
In some work we need a view showing more than one face of the object. Oblique projection is one way to do this. In oblique projection draw the front view the same as in ordinary projection. Then draw the side and top views at any angle from the front view. All lines scale their true dimensions.

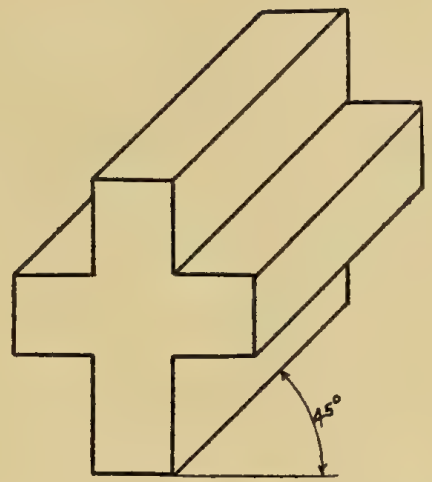
Directions for drawing Sheet #11

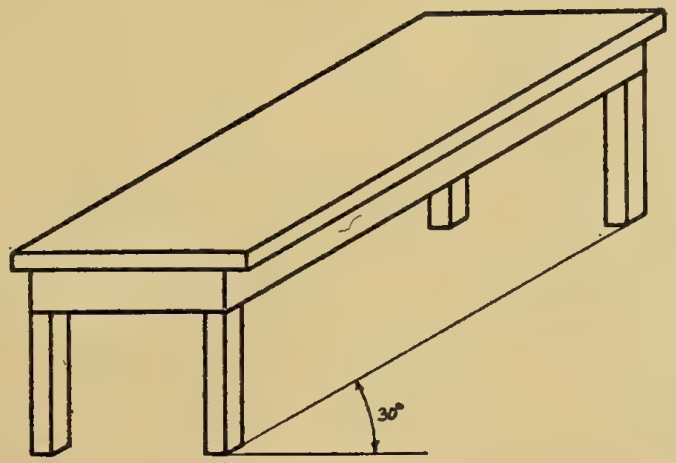
Isometric drawing is similar to oblique projection, but all lines except vertical lines are drawn at 30°. All lines scale their full dimensions. The table and steps on Sheets #10 & #11 are exactly the same. Note the difference in appearance. Sheet #1 of this set is an isometric drawing.

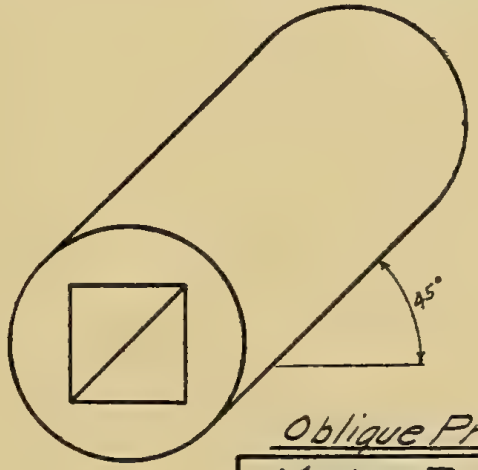
Modern Drafting
by
J. Frank Miller

JFM. 9-28-09









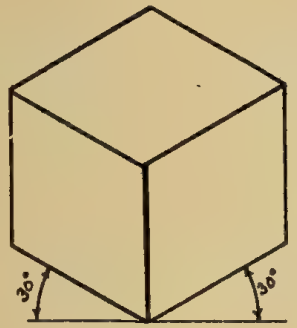
Oblique Projection

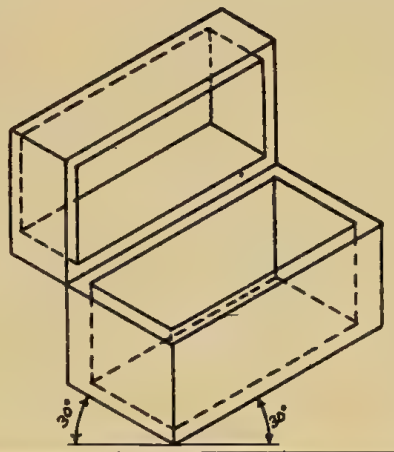
Modern Drafting
by
J. Frank. Miller.

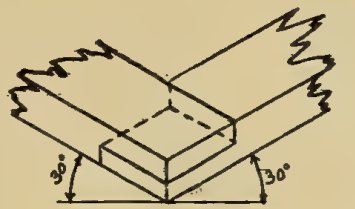
Scale 6"=1'0"

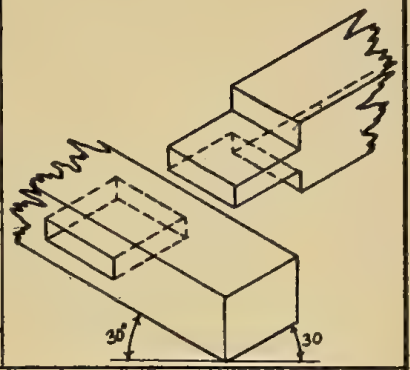
JFM 9-27-09

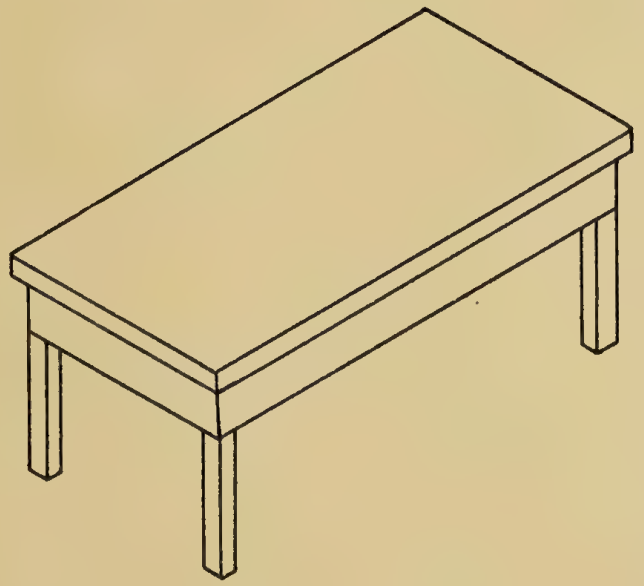
Sheet #11

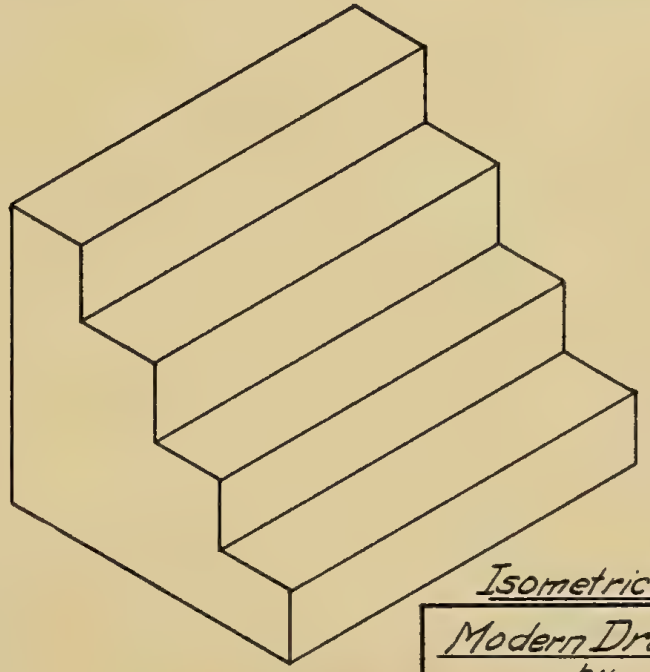












Isometric Drawing

Modern Drafting
by
J. Frank. Miller

Scale 6"=1'-0"

JFM 9-27-09

Shop Drawings

A shop drawing is a complete drawing contoining all necessary information so that the mechanic can make the piece without asking for further information. All dimensions and necessary views must be given so that he will know how large it is and how it looks. If you cannot make all this clear in ordinary views, sections must be drawn. A section is a view which you would see if the piece was sawed apart

Be sure you have given all dimensions, and notes about finish and material. Go over the finished sheet and ask yourself if you could make the piece from your drawing

Arrange all views, notes, etc. so as to make a pleasing sheet. Dont crowd your work, but arrange all views relating to one part together.

Your initials always appear in the title and notes oneach sheet, as shown on a following sheet. Thus each sheet acts as a recommendation for you, so you should do the best work you can. On a job that has many drawings the general notes are made on rubber stamps and stamped on each sheet. This saves much valuable time.

Tracing

When a drawing is finished it is either inked in or traced. If it is to be inked in the whole sheet is gone over using ink. The instruments are used just as in pencil work. and an ink line, figure, or letter made over each one in pencil.

If copies of the drawing are needed it must be traced. The tracing may be made on paper or tracing cloth. Tracing cloth is better and will stand handling better.

Tracing cloth has a smooth and a dullside. Generally the dull side is used to work on as it takes ink better. Take a piece of cloth and turn the smooth shiney side down. Stretch it over the drawing and tack it down with thumb tacks. Sprinkle fine chalk over it and rub the chalk in using your hand or a cloth. Brush or wipe offall the chalk that remains. You will be able to see the drawing clearly through the cloth, and you can easily trace it on the cloth. Keep the cloth stretched tight and use the instruments just as in pencil drawing. Use good waterproof india ink. (Higgins or equal)

Never dip your ruling pen into the ink. Use the quill on the stopper for filling it. Take your ruling pen and turn the thumb screw which will draw the two points together. Place the end of the quill between the points and draw it down leaving some ink in the pen. Don't put in too much or it will blot. Try the pen outside the border to see if it makes too heavy a line. The width of line is easily changed by turning the screw which pulls the points together. The bow pen and ink point for the compass is used the same way. Never allow ink to dry on your instruments. Keep them clean and you can do better work.

Draw your objects with heavy lines and use light lines for center lines and dimension lines. Never allow a drop of water to touch the tracing cloth, for it will be spoiled like a wilted collar

Modern Drafting
by
J. Frank. Miller.

JFM 1-30-10

Blue Prints

Many copies of drawings are often required and these are made by a process called blueprinting This process is similar to printing photographs. A printing frame is necessary and the glass should be larger than the tracing to be printed. Open the frame and lay the tracing on the glass, face down Then cover it with a piece of prepared blue print paper This paper can be obtained ready for use and must be kept dry and out of light It spoils very soon after being exposed to light, so cut it to size required in a dark room or a room having very little light Keep it under cover and have the frame all ready before you get out your paper. As soon as you put the paper in the frame, close the frame and look through the glass to see if the paper covers the tracing and be sure you can read the drawing through the glass If your tracing cannot be read you have it wrong side out and it must be changed When all is ready place the frame where the sun or strong light can strike the glass. If the light is bright your print will be done in from ½ to 3 minutes. This time varies with light and various papers The only way to do is to try to make a print and after it is exposed a few minutes, take it in and submerge it in clear cold water. Leave it in the water until all the greenish-yellow color is washed off. If the right exposure has been made the print will become a nice sky blue with white lines in 2 or 3 minutes If the color and lines are too pale, the exposure was not long enough If the color is dark and lines poor and not clean the exposure was too long Some times longer washing will make it clear if over exposed. Now hang the print up to dry across a cord or wire and you have a blue print.

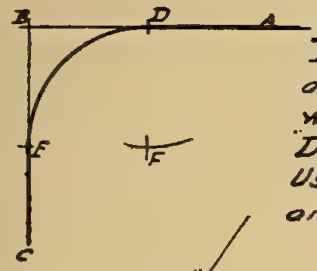
Notes

The previous sheets are not exactly shop drawings. They were given to teach the various principles of drawing. Following are a few examples of shop drawings, free hand sketches, general drawings, notes etc. The draftsman is required to go out and measure up a machine, make sketches, and then go to the drawing room and make the finished drawings to scale. Your sketches must show clearly the shape and size of all parts, or you will not be able to draw them in the drawing room Be very careful to get all dimensions required, clearance, finish, etc. before you leave the piece for it will save valuable time.

After learning the previous principles, make sketches of various parts of machines and draw them to scale The only way to learn is to handle the pieces yourself and become familiar with the various machines and parts of machines. Very little can be learned from copying drawings made by another, and a teacher who does this kind of teaching is very far from the modern methods.

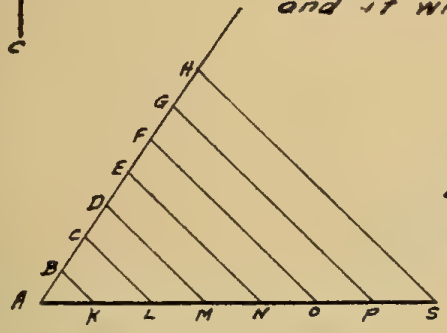
Modern Drafting
by
J. Frank. Miller.

J.F.M. 1-31-10



To draw a curve joining two straight lines

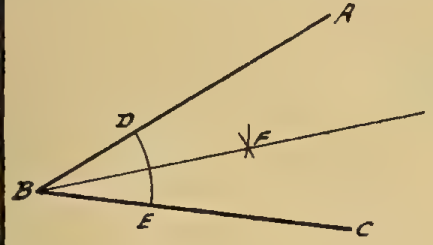
Draw the lines BA & BC. Suppose we want to draw a curve to a radius of ¾" and have it tongent to both lines. Set the compass to a radius of ¾" and with "B" as a center draw arcs cutting both lines at D & E Now with "D" & "E" as centers and a ¾" radius, describe arcs intersecting at F. Use "F" as a center and the required ¾" radius, draw the curve from E to D and it will fill the required conditions.



To divide a straight line into a given number of equal parts.

To divide the line "AS" into 7 equal parts, draw the line "AH" in any direction from the end of the line A. Divide, or rather set off, 7 equal spaces at any scale on AH. Draw a line through the last point "H" and the end of the line "S" Now draw parallel lines through each of the remaining points on "AH." If all the lines are parallel to HS they will divide the line AS as required.

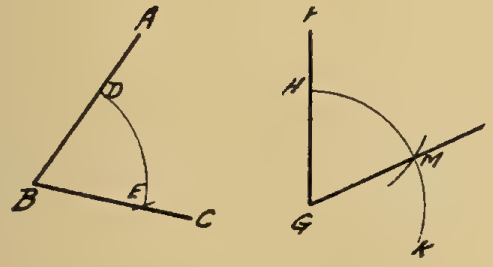
To bisect a given angle.



To bisect the angle ABC take any radius and draw the arc DE With D and E as centers and any radius, describe arcs intersecting at F. Draw a line from B through F, and it will bisect the angle ABC

ABF could be bisected in a like manner and we would have our angle divided into 4-8-16 etc. parts

To draw an angle any where equal to a given angle.



With B as a center and any radius, draw the arc DE in the given angle. Draw a line FG and with G as a center and the same radius as before, draw HK. With D as a center take a radius to E and use H as a center to draw an arc with the radius DE. This arc cuts the curved line HK at M, and by drawing GM we have an angle FGM equal to the given angle ABC.

General Instructions

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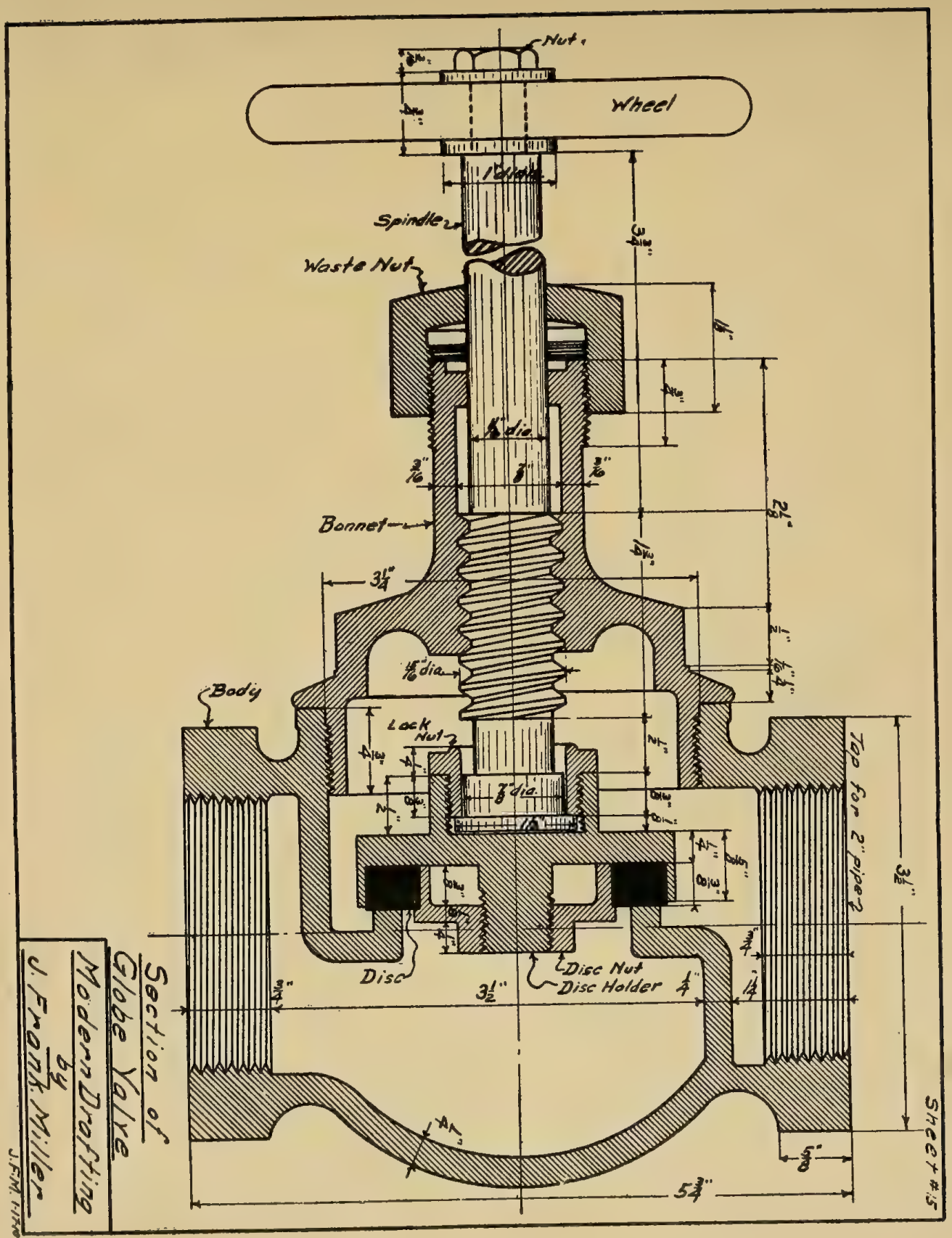
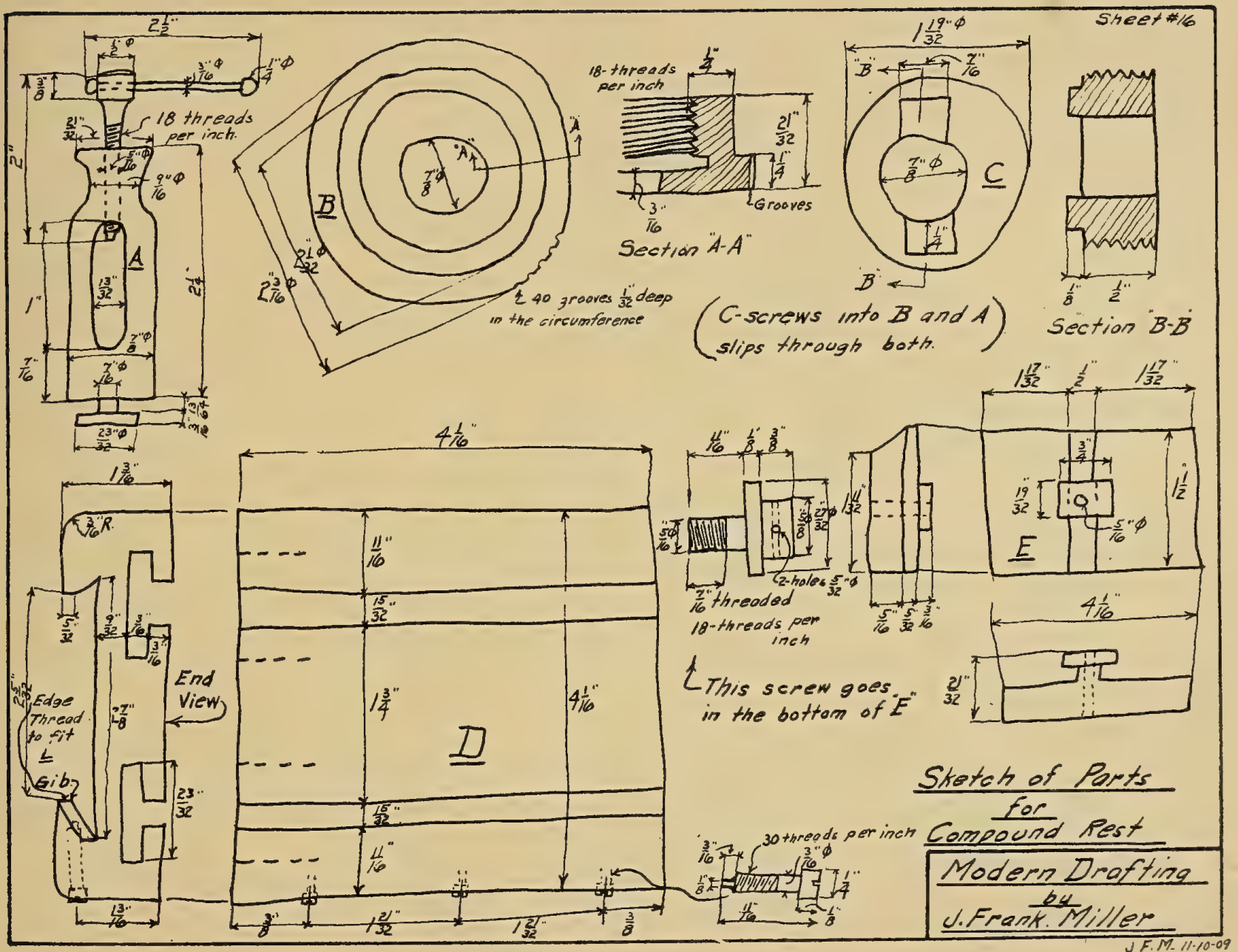
J. Frank Miller.

J.F.M. 9-14-18

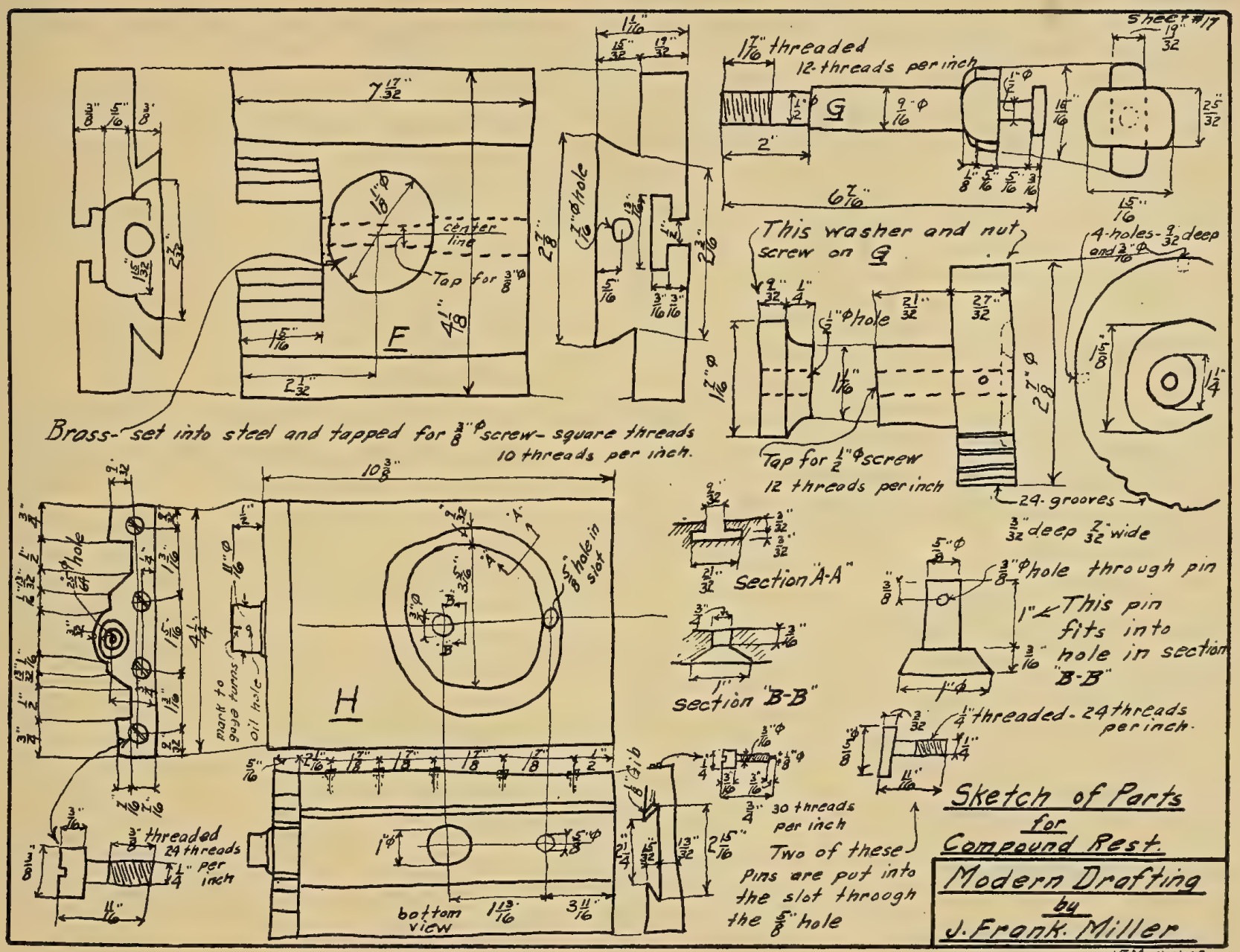

Nut
Wheel
Spindle
Waste Nut
Bonnet
Body
Lock Nut
Disc
Disc Nut
Disc Holder
Top for 2" pipe
Section of Globe Valve
Modern Drafting
by
J. Frank Miller
Sheet #5



Sketch of Parts for Compound Rest

Modern Drafting by J. Frank. Miller

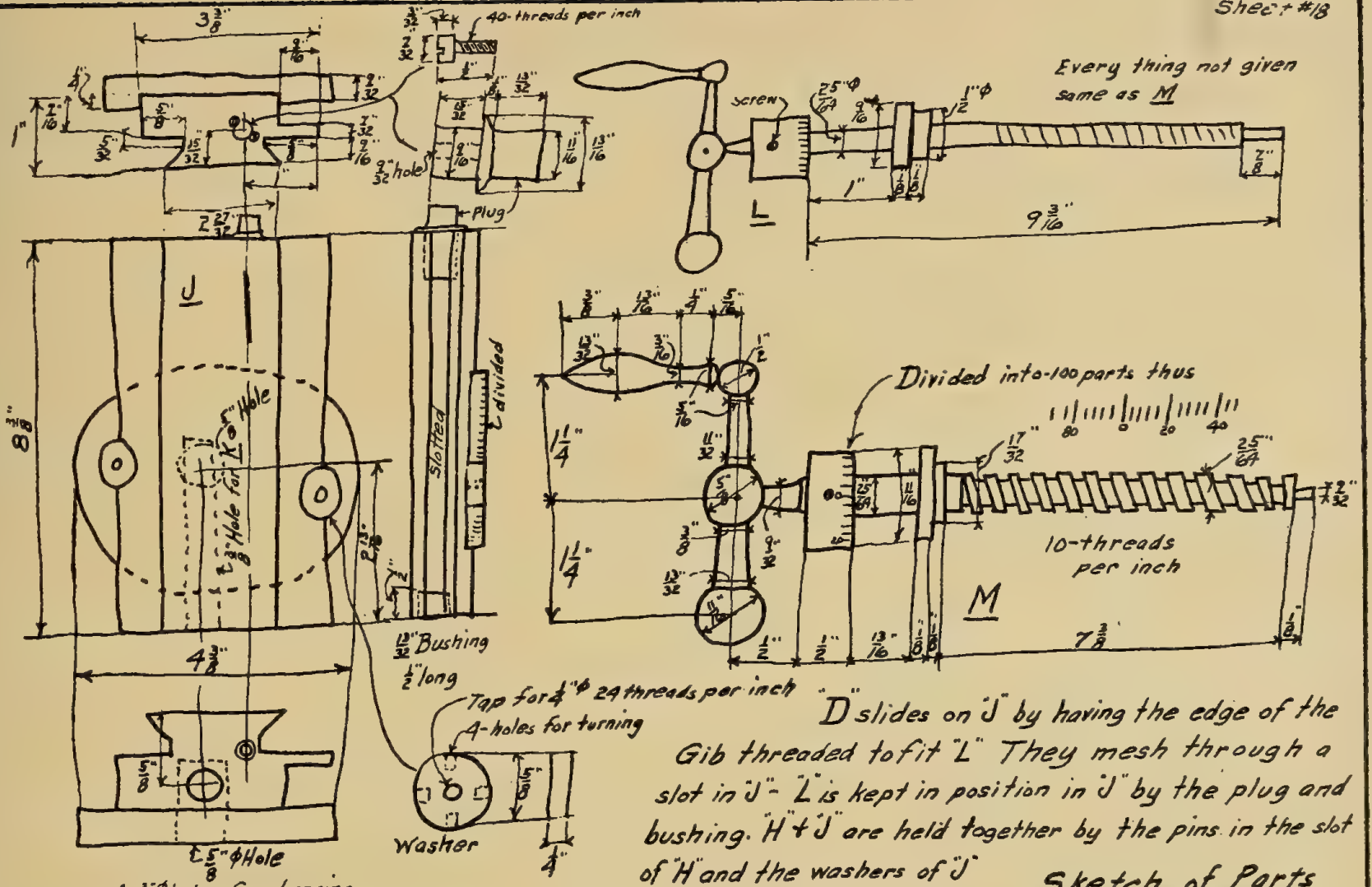
J F. M. 11-10-09


F
G
H
Brass- set into steel and tapped for 3/8" ϕ screw- square threads 10 threads per inch.
Tap for 3/8" ϕ
center line
1" ϕ hole
1/2" ϕ hole
1 1/16" threaded 12 threads per inch
This washer and nut screw on G
4 holes- 9/32 deep and 3/16" ϕ
Tap for 1/2" ϕ screw 12 threads per inch
24 grooves 3/32" deep 2/32" wide
Section "A-A"
Section "B-B"
3/8" ϕ hole through pin
This pin fits into hole in section "B-B"
1/4" threaded- 24 threads per inch.
3/8" threaded 24 threads per inch
5/8" ϕ hole in slot
mark to gage turns
oil hole
bottom view
30 threads per inch
Two of these pins are put into the slot through the 5/8" hole

Sketch of Parts for Compound Rest.

Modern Drafting by J. Frank. Miller

JFM 11-11-09



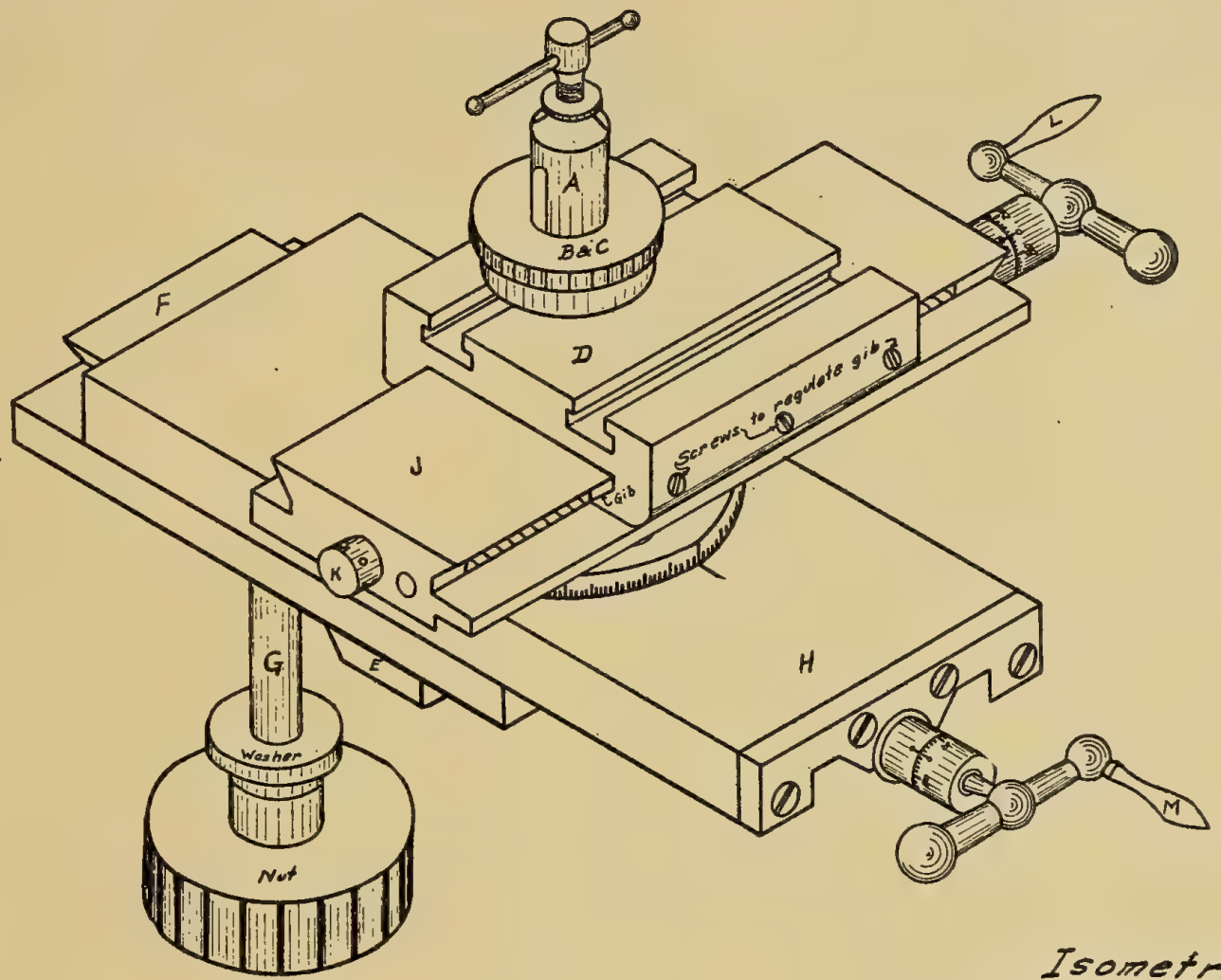
"D" slides on "J" by having the edge of the Gib threaded to fit "L" They mesh through a slot in "J" - "L" is kept in position in "J" by the plug and bushing. "H" + "J" are held together by the pins in the slot of "H" and the washers of "J"

By loosening the washers "J" may be turned at any angle. "K" clamps "J" to "H" by being pushed into "J" until it goes through the pin in "H" - "K" has the flattened section so as to wedge by turning.

Sketch of Parts for Compound Rest

Modern Drafting by J. Frank. Miller

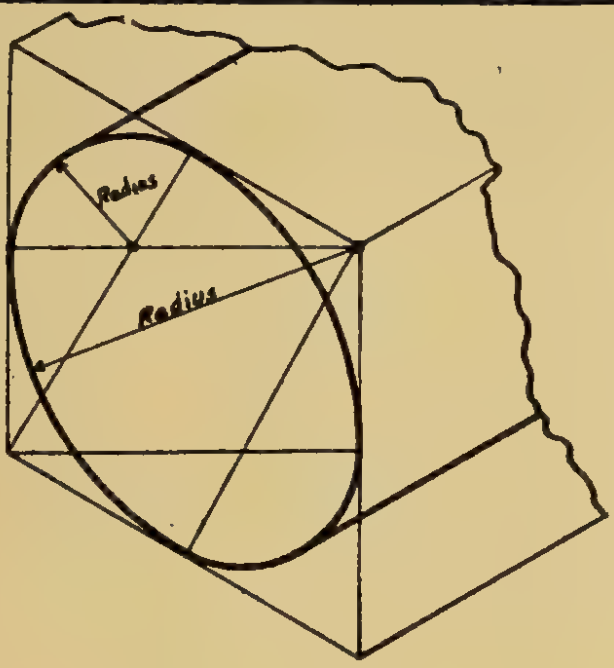
JFM-11-11-09

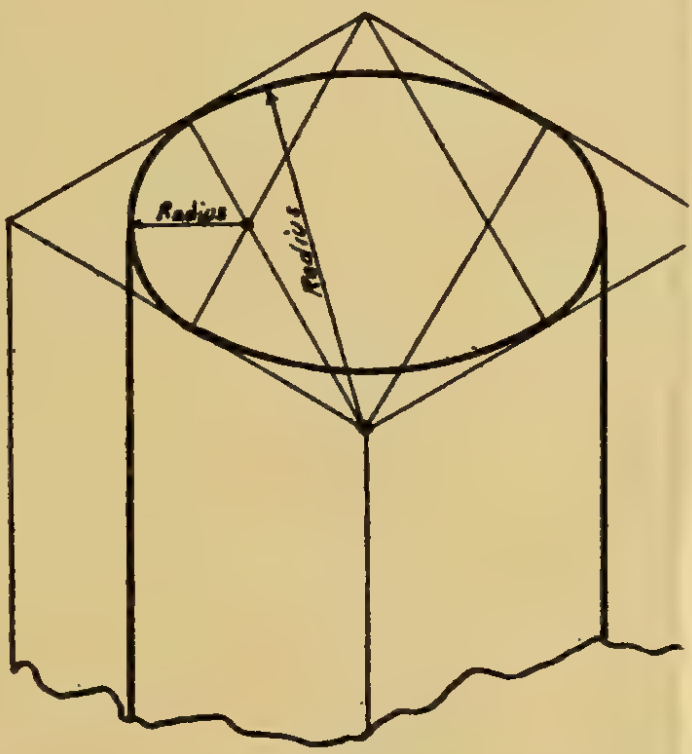


Isometric of
Compound Rest

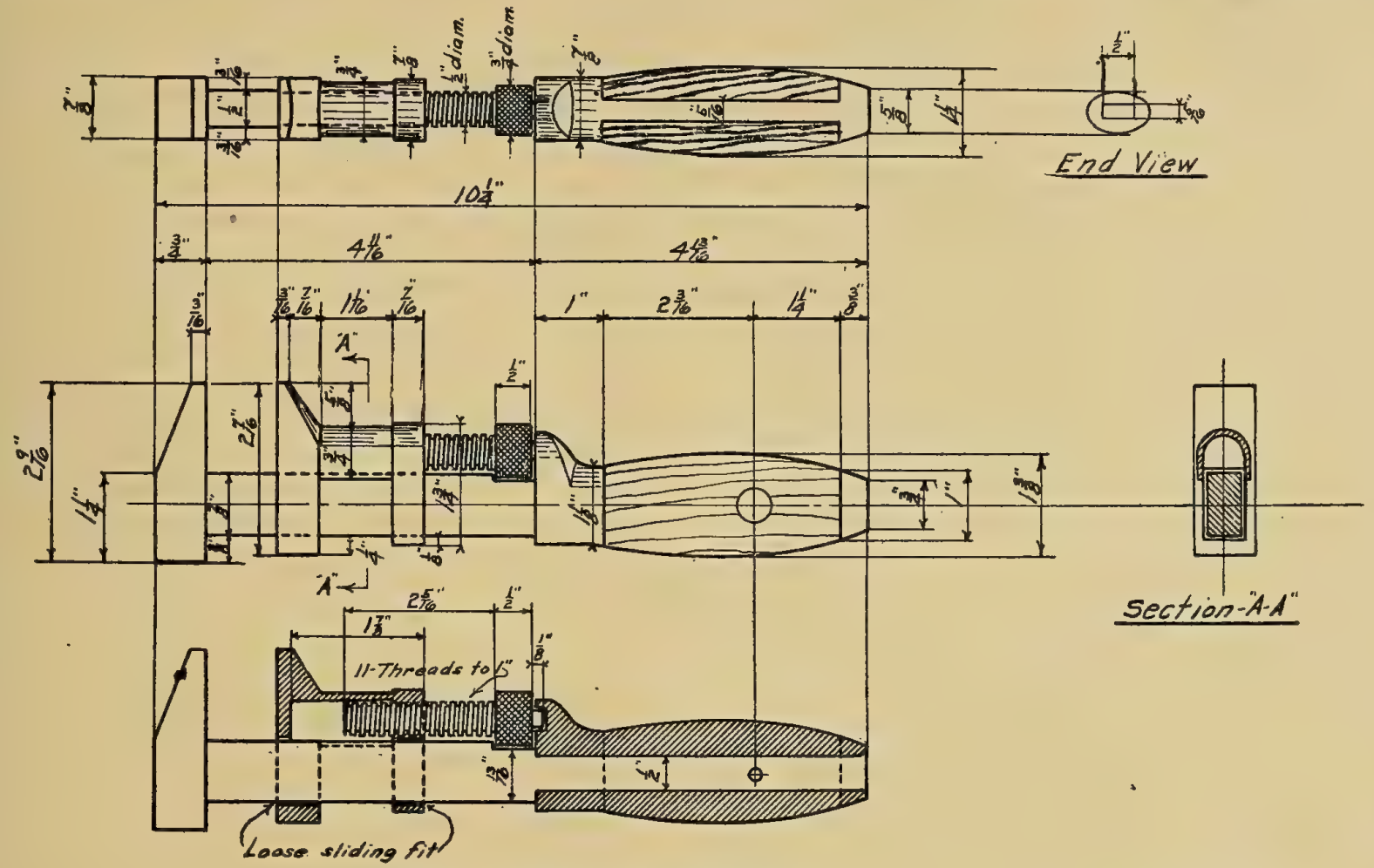
Modern Drafting
by
J. Frank. Miller

J.F.M. 1-16-10





Isometrics of Circles



Square threads to work easily.

Wooden handle to be riveted on.

Material steel.

Not finished except handle.

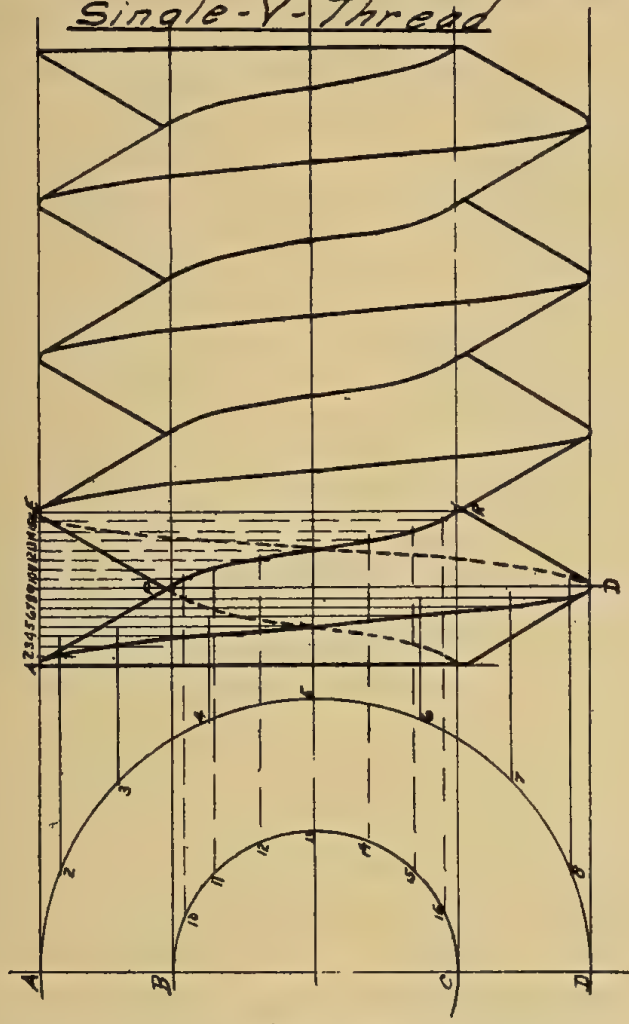
Monkey Wrench

Modern Drafting
by
J. Frank. Miller.

Scale-6"-1'-0"

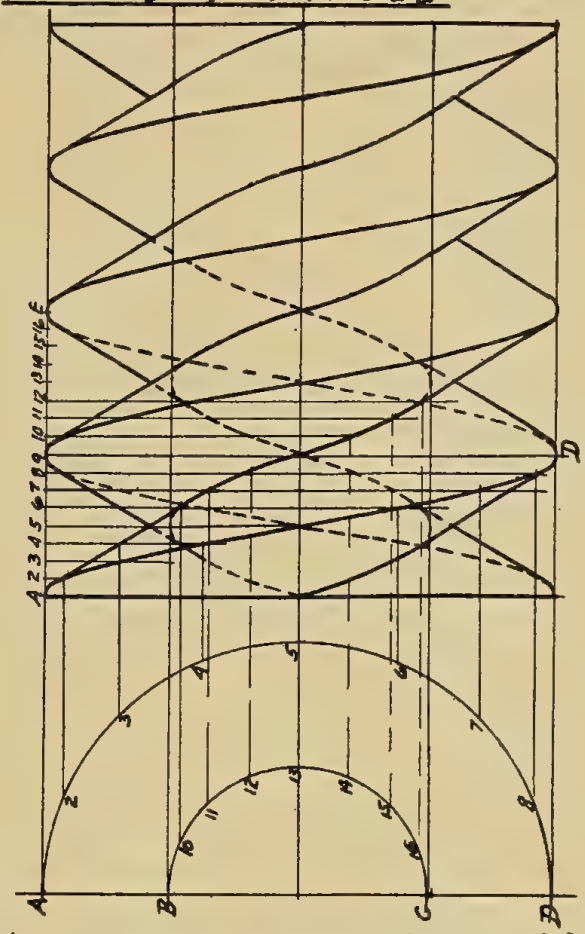
J.F.M. 11-8-09

Single "V" Thread



AD = outside diameter. AB + CD = depth of thread
AE = pitch. Divide the outside diameter as shown and divide the pitch into the same number of equal parts. Project down and over from similar points and draw a helix through the intersections. Do the same with points on BC for the small helix. AP-EP-DR-etc are drawn tangent to the 2 helices

Double "V" Thread



This is just like the other. Start at "A" and draw a single thread ADE. Then start at "9" or half way between "A" + "E" and draw another thread exactly like the first one.

True Threads

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by
J. Frank Miller

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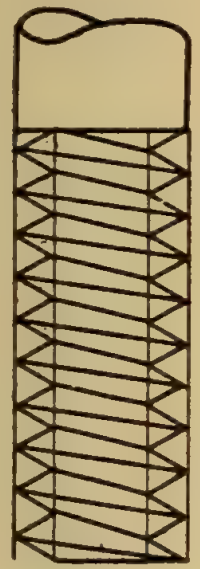
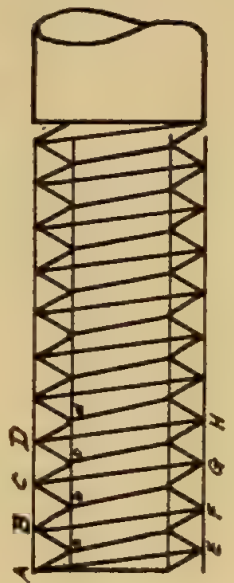
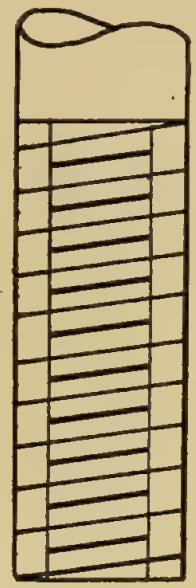


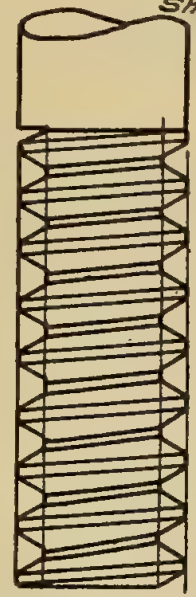
Left Hand



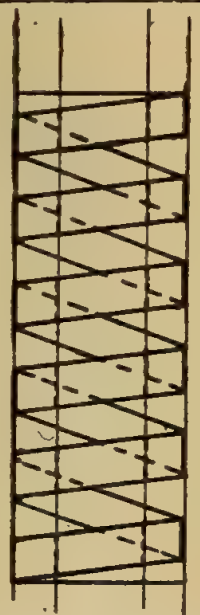
Right Hand



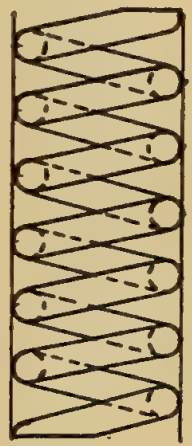
Common Method



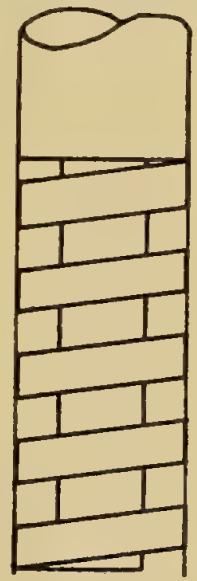
Sellers or United States Std.



Square Spring



Round Spring



Square Thread

In ordinary work we havent time to draw the actual views of threads so we use these methods. To draw the right hand V thread shown above; draw two light lines and step off A-B-C-D and E-F-G-H etc. equal to the pitch of your thread. The lines must be a distance apart equal to the diam. of bolt. Use 60° triangle to get Aa- Ba- etc.

Conventional Thread

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by
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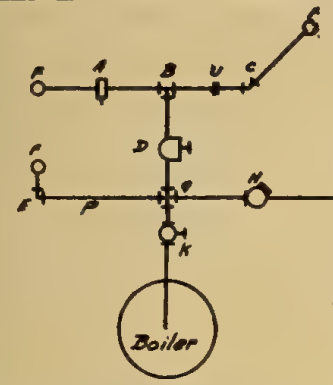
JFM-3-10-10



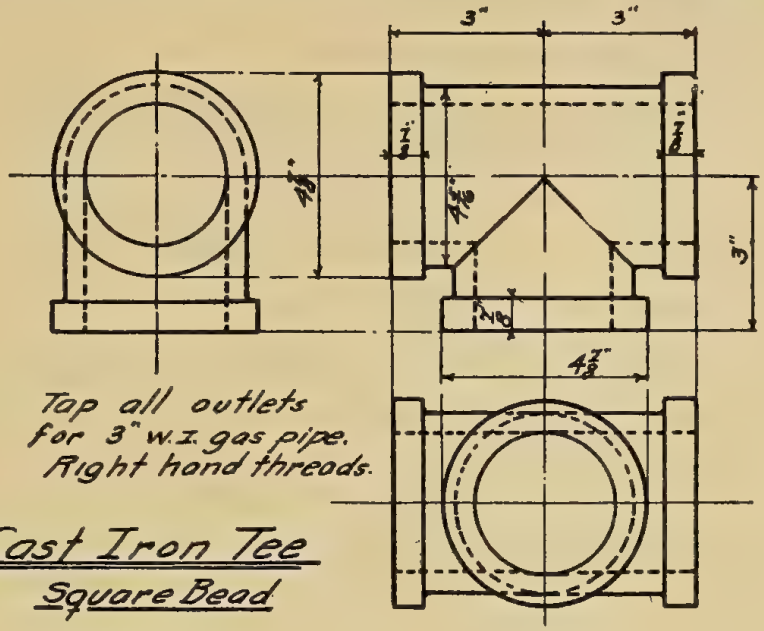
A = cock
B = Tee
C = 45° elbow
D = gate valve
E = elbow
F = risers
G = Cross
H = check valve
K = globe valve
P = pipe
U = union

Main pipe

Return pipe

Drip pipe

Conventional Pipe Fittings



Tap all outlets for 3" W.I. gas pipe. Right hand threads.

3" Cast Iron Tee
Square Bead

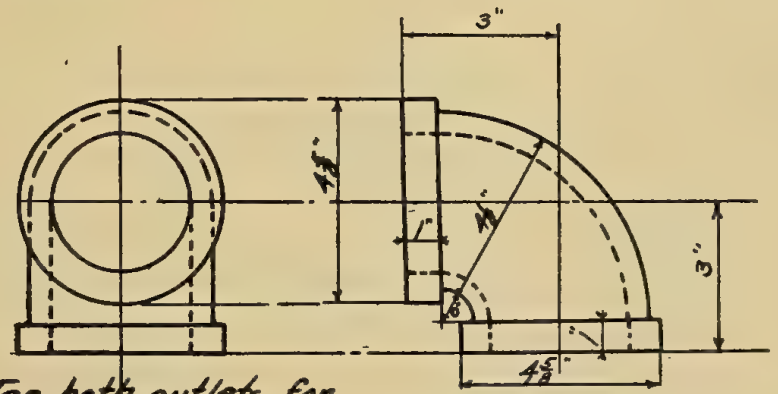
The sizes of pipe and pipe fittings are given in the various Plumbers Catalogues.

When we speak of a 3" W.I Gas Pipe we mean a pipe having an inside diameter of about 3" This pipe has an actual inside diameter of 3.06" and an actual outside diameter of 3.50"

The threads are cut on the outside of the pipe. (Either right or left hand)

The threads are cut on the inside of fittings. (Either right or left hand)

The ends of the pipes are screwed into the fittings. The most common fittings are Elbows, Tees, Crosses, (either plain or with side outlets) Couplings, Flanges, Unions, Plugs, and Valves.



Tap both outlets for 3" W.I. Gas Pipe Right hand threads

3" Cast Iron Elbow

Pipe Fittings

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by
J. Frank. Miller

J.F.M. 11/3/10

Title and Notes

General Notes.
All Material Medium O. H. Steel.
All Rivets 7/8" diam: unless noted.
All Open Holes 15/16" diam. unless noted.
All Holes in metal less than 3/4" thick to be punched 1/16" larger than diam. of Rivet.
All Holes in metal 3/4" thick and over to be punched 1/8" smaller and reamed 1/16" large than the diam. of Rivet.
Milling - as noted.

Surfaces in contact to receive one heavy coat of the N. Y. Central Standard Red Lead Paint on each surface. Parts inaccessible after erection to receive two heavy coats of the above paint. Erection marks, contract number and sub-area mark shall appear on each piece on painted surface. Material and workmanship to be in accordance with N. Y. Central Specification "B" for steel work for Grand Central Yard Improvements.

Paint-All material to receive one shop coat of N.Y. Central Standard Red Lead Paint.
Material Ord. on E. S.

Girders "G7" & "G8"
Park Avenue Viaduct

CONTRACT No. 2430
ORDER No. 2769 DRAWN BY J.F.M.
CARD No. 921 CHECK'D BY [illegible]
SHEET No. 27 DATE 5-18-1910
MILLIKEN BROS., INC.
MILLIKEN, STATEN ISLAND, N. Y.
DRAUGHTING DEPT.

J.F.M.-1-5-1910

7

Decimal Parts

Decimal Parts of a Foot

	0	1	2	3	4	5	6	7	8	9	10	11	Decimal parts of an inch	
	.0000	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167		
1/32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193	1/32	.0313
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219	1/16	.0625
3/32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245	3/32	.0938
1/8	.0104	.0937	.1771	.2604	.3437	.4271	.5104	.5937	.6771	.7604	.8437	.9271	1/8	.1250
5/32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297	5/32	.1563
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323	3/16	.1875
7/32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349	7/32	.2188
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375	1/4	.2500
9/32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401	9/32	.2813
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427	5/16	.3125
11/32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453	11/32	.3438
3/8	.0312	.1146	.1979	.2812	.3646	.4479	.5312	.6146	.6979	.7812	.8646	.9479	3/8	.3750
13/32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505	13/32	.4063
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531	7/16	.4375
15/32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557	15/32	.4688
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583	1/2	.5000
17/32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609	17/32	.5313
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635	9/16	.5625
19/32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661	19/32	.5938
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688	5/8	.6250
21/32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714	21/32	.6563
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740	11/16	.6875
23/32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766	23/32	.7188
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792	3/4	.7500
25/32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818	25/32	.7813
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844	13/16	.8125
27/32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870	27/32	.8438
7/8	.0729	.1562	.2396	.3229	.4062	.4896	.5729	.6562	.7396	.8229	.9062	.9896	7/8	.8750
29/32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922	29/32	.9063
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948	15/16	.9375
31/32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974	31/32	.9688

J.F.M. 12-10-09

Mensuration

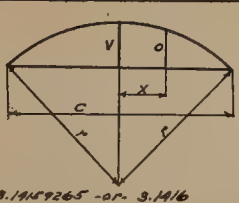
Area of a Parallelogram = Base × perpendicular height
" " " Triangle = Base × ½ perpendicular height
" " " Circle = Diameter squared × 0.7854
" " " Circle = Radius squared × 3.1416
" " Sector of a Circle = Arc × ½ radius
" " Segment " " = Area of sector of equal radius and arc, minus area of triangle.
" " a Parabola = Base × ⅔ height
" " an Ellipse = Longest diameter × shortest diameter × 0.7854
" " a cycloid = Area of generating circle × 3
" " any regular polygon = Sum of its sides × perpendicular from its centre to one of its sides ÷ 2
" " a trapezoid = Altitude × ½ sum of parallel sides
Surface of a Cylinder = Area of both ends + (length × circumfrence)
" " Cone = Area of base + (circumfrence of base × ½ slant height)
" " Sphere = Diameter squared × 3.1416
" " Frustum = Area of both ends + (sum of girt of both ends times ½ slant height)
" " Cylindrical Ring = Thickness of ring + inner diameter × thickness × 9.8698
" " a Segment = Height of segment × whole circumfrence of a sphere of which it is a part
" " Cube = Area of one side × 6
" " " Sphere = Circumfrence × diameter
Volume of a Cylinder = Area of one end × length
" " " Sphere = Cube of diameter × 0.5236
" " Segment of a Sphere = (Cube of height + three times square of radius of base × height) times 0.5236
" " Cone or Pyramid = Area of base × ⅓ perpendicular height
" " Frustum of Cone = (Product of diameters of both ends + sum of their squares) × perpendicular height × 0.2618
" " " " Pyramid = (sum of areas of both ends + square root of their product) × ⅓ perpendicular height
" " a wedge = Area of base × ½ perpendicular height
" " Frustum of a Wedge = Sum of areas of 2 ends × ½ perpendicular height
" " a Ring = Thickness × inner diam. × square of thickness × 2.4674
Circumfrence of a Circle = Diameter × 3.1416
Side of an Equivalent Square = Diameter × 0.8862
" " " Inscribed Square = Diameter × 0.7071
" " " " Cube = Radius of a sphere × 1.1547
" " " " Equilateral Triangle = Diameter × 0.86
Length of arc = No. of degrees × diam. × 0.008727

In figuring irregular figures divide them into rectangles, triangles, etc and calculate each part separately.

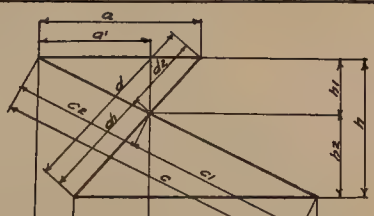
JFM. 3-12-10

(III)

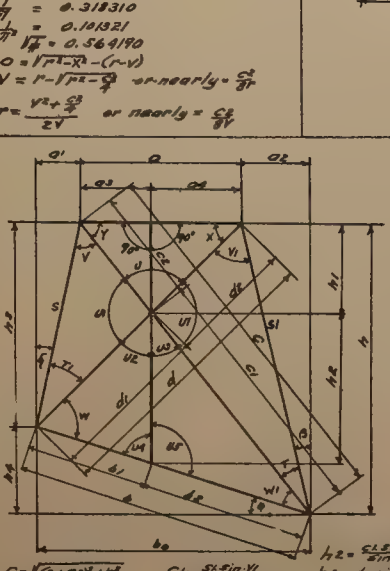
Mensuration (Continued)



$\pi = 3.14159265$ -or- 3.1416
$\log. \pi = 0.4971499$
$\sqrt{\pi} = 1.772454$
$\pi^2 = 9.869604$
$\frac{1}{\pi} = 0.318310$
$\frac{1}{\sqrt{\pi}} = 0.101321$
$\sqrt{\frac{1}{\pi}} = 0.564190$
$O = \sqrt{r^2 - X^2} - (r - V)$
$V = r - \sqrt{r^2 - \frac{O^2}{4}}$ or nearly $= \frac{O^2}{8r}$
$r = \frac{V^2 + \frac{O^2}{4}}{2V}$ or nearly $= \frac{O^2}{8V}$



$c = \sqrt{(b+b2)^2 + h^2}$
$c1 = \sqrt{(b-b1)^2 + h2^2}$
$c2 = \sqrt{a1^2 + h1^2}$
$d = \sqrt{(a-b2)^2 + h^2}$
$d1 = \sqrt{b1^2 + h2^2}$
$d2 = \sqrt{(a-a1)^2 + h1^2}$



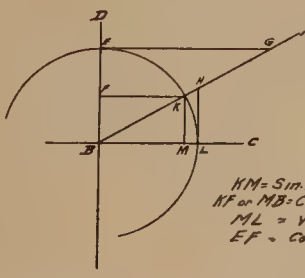
$\text{Tan. } X = \frac{h3}{a+a1}$ $\quad \text{Sin. } X = \frac{h3}{d}$
$\text{Tan. } Y = \frac{h}{a+a2}$ $\quad \text{sin. } Y = \frac{h}{d}$
$U1 = X + Y$ $\quad V = 90° + \angle - Y$
$V1 = 90° + \beta - X$
$\text{Tan. } \angle = \frac{a1}{h3}$ $\quad \text{Sin. } \angle = \frac{a1}{s1}$
$\text{Tan } \beta = \frac{a2}{h}$ $\quad \text{Sin. } \beta = \frac{a2}{s1}$
$W = (90° + \Phi) - (\angle + T1)$
$W1 = 90° - (\Phi + T + \beta)$
$U2 = 90° - X$
$U3 = 90° - Y$
$\text{Tan. } \Phi = \frac{h4}{b0}$
$\text{Sin. } \Phi = \frac{h4}{b}$
$X = 180° - (Y + V + T1)$
$U = 180° - U1$
$U2 = 180° - (W + U4)$
$U4 = 180° - U5$

$C = \sqrt{(a+a2)^2 + h^2}$ $\quad C1 = \frac{S1 \cdot \sin. V1}{\sin. U1}$ $\quad h2 = \frac{C1 \cdot \sin. W1}{\sin. U2}$ $\quad a = \frac{S \cdot \sin. T1}{\sin. X}$ $\quad b = \frac{S1 \cdot \sin. V1}{\sin. W}$
$S1 = \sqrt{h^2 + a2^2}$ $\quad a3 = \sqrt{a a1 - h^2}$ $\quad h2 = \frac{d1 \cdot \sin. W}{\sin. U3}$ $\quad d2 = \frac{S1 \cdot \sin. T}{\sin. U1}$ $\quad C = \frac{S \cdot \sin. (W + T1)}{\sin. W1}$
$C2 = \frac{a \cdot \sin. X}{\sin. U}$ $\quad b = \sqrt{h a^2 + b a^2}$ $\quad d = \sqrt{(a+a1)^2 + h2^2}$ $\quad d1 = \frac{d \cdot \sin. U}{\sin. U1}$ $\quad a4 = \sqrt{a a1 - h^2}$
$C2 = \frac{S \cdot \sin. T}{\sin. U}$ $\quad b1 = \frac{d1 \cdot \sin. W}{\sin. U4}$ $\quad S = \sqrt{h3^2 + a1^2}$ $\quad d1 = \frac{d \cdot \sin. U}{\sin. U1}$ $\quad a4 = a - a3$
$dc = \frac{a \cdot \sin. Y}{\sin. U}$ $\quad h1 = a4 \cdot \text{Tan. } X$ $\quad b0 = a1 + a + a2$
$b2 = \frac{C1 \cdot \sin. U2}{\sin. U5}$

JFM 3-14-10

(IV)

Trigonometrical Functions.



—Abbreviations—

Sin.	stands for	Sine	
Cos	"	Co-sine	
Vers.	"	Versed-sine	
Covers.	"	Co-versed-sine	
Tan.	"	Tangent	
Cot.	"	Co-tangent	
Sec.	"	Secant	
Cosec.	"	Co-secant	

KM = Sin. ∠ABC
KF or MB = Cos. ∠ABC
ML = Vers. ∠ABC
EF = Co-vers. ∠ABC
HL = tan. ∠ABC
EG = cot. ∠ABC
BH = sec. ∠ABC
BG = Co-sec. ∠ABC

The sin. of an angle = opposite side divided by the hypotenuse
" Cos. " " " = adjacent " " " " "
" tan. " " " = opposite " " " adjacent side.
" cot. " " " = adjacent " " " opposite "
" sec " " " = hypotenuse " " = " adjacent "
" cosec " " = " " " " opposite "

$\text{Sin. } \angle ABC = \frac{KM}{KB}$ $\quad \text{Cot. } \angle ABC = \frac{BL}{HL}$ $\quad \text{Sin. } \angle ABD = \frac{FK}{KB}$ $\quad \text{Cot. } \angle ABD = \frac{FB}{FG}$

$\text{Cos. } \angle ABC = \frac{MB}{KB}$ $\quad \text{Sec. } \angle ABC = \frac{BH}{BL}$ $\quad \text{Cos. } \angle ABD = \frac{FB}{KB}$ $\quad \text{Sec. } \angle ABD = \frac{BG}{BE}$

$\text{Tan. } \angle ABC = \frac{HL}{BL}$ $\quad \text{Cosec. } \angle ABC = \frac{BH}{HL}$ $\quad \text{Tan. } \angle ABD = \frac{EG}{FB}$ $\quad \text{Cosec. } \angle ABD = \frac{BG}{EG}$

The sin. ∠ABC = Cos. ∠ABD $\quad$ Cos. ∠ABC = Sin ∠ABD
Sec. ∠ABC = Cosec. ∠ABD $\quad$ Cosec. ∠ABC = Sec. ∠ABD
Tan. ∠ABC = Cot. ∠ABD $\quad$ Cot. ∠ABC = Tan. ∠ABD

The square of the sin. of any arc or angle = 1 minus the square of its cos.
" " " " Cos. " " " " " = 1 " " " " " sin
The vers. of any arc or angle = 1 minus the cos. of the arc or angle
" covers " " " " " " = " " sin. " " " "
" tan. " " " " " = its sin divided by its cos.
" cot " " " " = " cos. " " " sin
" tan. " " " " times its cot. = 1
" " " " " " " = 1 divided by its cot.
" cot " " " " = 1 " " " tan.
" sec " " " " = 1 " " " cos.
" cosec " " " " = 1 " " " sin
The complement of an arc or angle = 90° minus the arc or angle
" supplement " " " = 180° " " " "

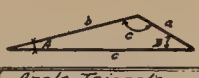
JFM 6-25-10

(V)

Solving Triangles.

Right

Oblique



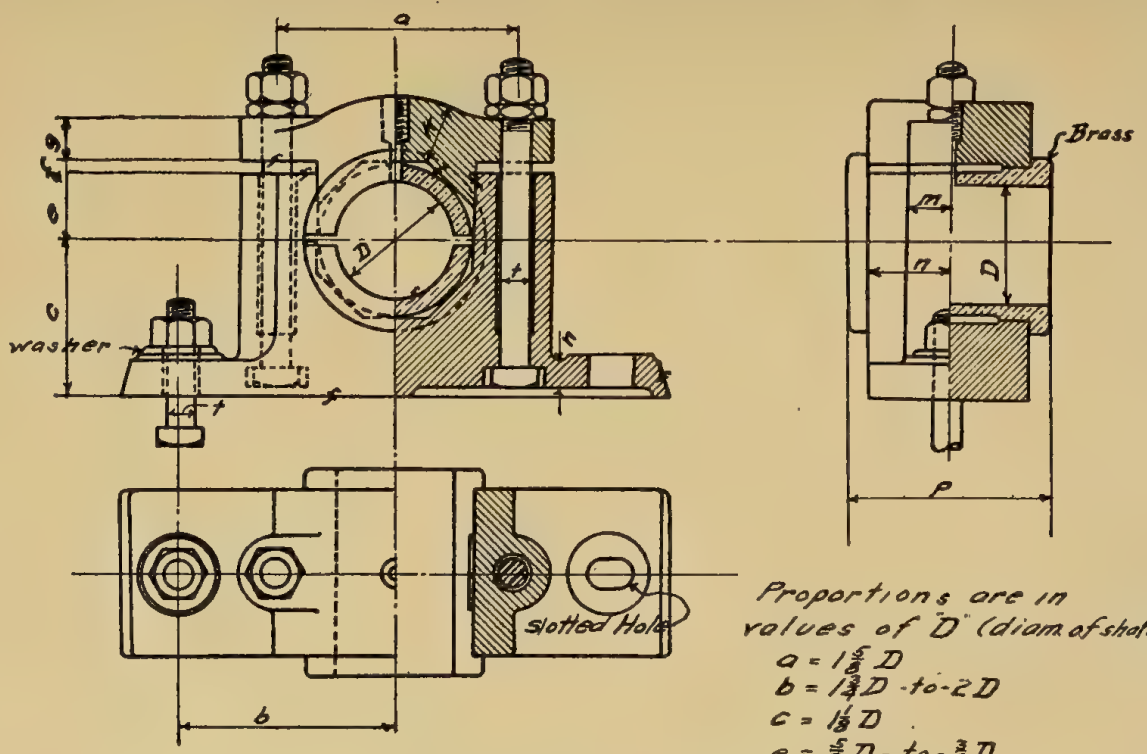
Given	Parts to find — in a — Right-Angle Triangle.					
	a	b	c	∠A	∠B	∠C
a - b			$\sqrt{a^2-b^2}$	$\cos\angle C = \frac{b}{a}$		$\sin\angle B = \frac{b}{a}$
a - c		$\sqrt{a^2-c^2}$		$\sin\angle C = \frac{c}{a}$		$\cos\angle B = \frac{c}{a}$
a - ∠C		a × Cos. ∠C	a × Sin. ∠C			90° - ∠C
b - c	$\sqrt{b^2+c^2}$				$\tan\angle C = \frac{c}{b}$	$\cot\angle B = \frac{c}{b}$
b - ∠C	$\frac{b}{\cos\angle C}$		b × Tan ∠C			90° - ∠C
c - ∠C	$\frac{c}{\sin\angle C}$	c × Cot ∠C				90° - ∠C

Given	Parts to find in an Oblique Angle Triangle					
	a	b	c	∠A	∠B	∠C
a - b - c				$\cos A = \frac{b^2+c^2-a^2}{2bc}$	$\cos B = \frac{a^2+c^2-b^2}{2ac}$	$\cos C = \frac{a^2+b^2-c^2}{2ab}$
b - c - ∠A	$\sqrt{b^2+c^2-2bc\cos A}$				$\tan B = \frac{b\sin A}{c-b\cos A}$	$\tan C = \frac{c\sin A}{b-c\cos A}$
a - c - ∠B		$\sqrt{a^2+c^2-2ac\cos B}$		$\tan A = \frac{a\sin B}{c-a\cos B}$		$\tan C = \frac{c\sin B}{a-c\cos B}$
a - b - ∠C			$\sqrt{a^2+b^2-2ab\cos C}$	$\tan A = \frac{a\sin C}{b-a\cos C}$	$\tan B = \frac{b\sin C}{a-b\cos C}$	
a - b - ∠A			$\frac{a\sin C}{\sin A}$		$\sin B = \frac{b\sin A}{a}$	180° - (A+B)
a - b - ∠B			$\frac{b\sin C}{\sin B}$	$\sin A = \frac{a\sin B}{b}$		180° - (A+B)
a - c - ∠A		$\frac{a\sin B}{\sin A}$			180° - (A+C)	$\sin C = \frac{c\sin A}{a}$
a - c - ∠C		$\frac{c\sin B}{\sin C}$		$\sin A = \frac{a\sin C}{c}$	180° - (A+C)	
b - c - ∠B	$\frac{b\sin A}{\sin B}$			180° - (B+C)		$\sin C = \frac{c\sin B}{b}$
b - c - ∠C	$\frac{c\sin A}{\sin C}$			180° - (B+C)	$\sin B = \frac{b\sin C}{c}$	
a - ∠A - ∠B		$\frac{a\sin B}{\sin A}$	$\frac{a\sin C}{\sin A}$			180° - (A+B)
a - ∠A - ∠C		$\frac{a\sin C}{\sin A}$	$\frac{a\sin C}{\sin A}$		180° - (A+C)	
a - ∠B - ∠C		$\frac{a\sin B}{\sin A}$	$\frac{a\sin C}{\sin A}$	180° - (B+C)		
b - ∠A - ∠B	$\frac{b\sin A}{\sin B}$		$\frac{b\sin C}{\sin B}$			180° - (A+B)
b - ∠A - ∠C	$\frac{b\sin A}{\sin B}$		$\frac{b\sin C}{\sin B}$		180° - (A+C)	
b - ∠B - ∠C	$\frac{b\sin A}{\sin B}$		$\frac{b\sin C}{\sin B}$	180° - (B+C)		
c - ∠A - ∠B	$\frac{c\sin A}{\sin C}$	$\frac{c\sin B}{\sin C}$				180° - (A+B)
c - ∠A - ∠C	$\frac{c\sin A}{\sin C}$	$\frac{c\sin B}{\sin C}$			180° - (A+C)	
c - ∠B - ∠C	$\frac{c\sin A}{\sin C}$	$\frac{c\sin B}{\sin C}$		180° - (B+C)		

JFM 6-26-1910

(VI)

Pillow Blocks



Material Cast Iron Except Bushing which is Brass.
All surfaces marked "f" to be finished, or milled.

Pedestals, Pillow Block, Bearing or Journal-box all mean the same thing.

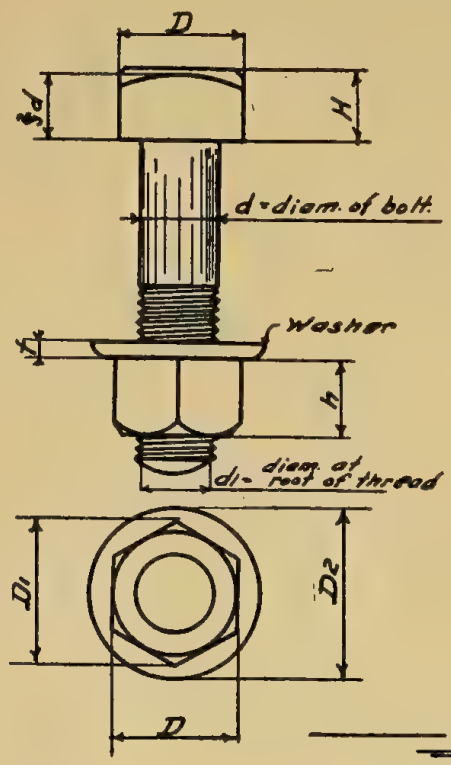
Proportions are in values of "D" (diam. of shaft)

$a = 1\frac{5}{8}D$
$b = 1\frac{3}{4}D$ -to- $2D$
$c = 1\frac{1}{8}D$
$e = \frac{5}{8}D$ - to - $\frac{3}{4}D$
$f = \frac{1}{16}D$ - to - $\frac{1}{8}D$
$g = \frac{3}{8}D$
$h = \frac{1}{4}D$ - to - $\frac{1}{2}D$
$K = \frac{5}{16}D$
$m = \frac{1}{4}D$
$n = \frac{5}{16}D$ - to - $\frac{7}{16}D$
$p = 1\frac{1}{2}D$ - to - $2D$
$t = \frac{1}{4}D$

The cap is held to the block by two bolts which have lock nuts. The bolt holes in the base of the block are slotted, or elongated in order to allow adjustment.

J.F.M. 4-13-10

Bolts



For Rough Work

$D = 1\frac{1}{2}d + \frac{1}{8}"$
$D_1 = 1.73d + .14"$ for hexagonal
$D_1 = 2.12d + .18"$ square
$D_2 = 1\frac{1}{8} D_1$
$h = d$
$t = .15d$
$H = \frac{1}{2}D$

For Finished Work

$D = 1\frac{1}{2}d + \frac{1}{16}"$
$D_1 = 1.73d + .07"$ for hexagonal
$D_1 = 2.12d + .09"$ " square
$D_2 = 1\frac{1}{8} D_1$
$h = d - \frac{1}{16}"$
$t = .15d$
$H = d - \frac{1}{16}"$

Strength of Bolts

P = total load on bolt
d_1 = diameter at root of thread
a = area of cross section at root of thread
S_w = safe working stress in pounds per sq. inch; which is 7000 to 8000 lbs per sq. inch for constant load
5000 to 6000 " " " " variable stress
3000 to 6000 " " " " cylinder heads
Above stresses for good wrought iron bolts

For tension $P = a S_w$ $\quad a = \frac{P}{S_w}$ $\quad d_1 = 2\sqrt{\frac{P}{\pi S_w}}$

Find diameter of bolt to carry a steady stress of 15000 lbs. use 8000 lbs. working stress.

$a = \frac{P}{S_w}$ or $a = \frac{15000}{8000} = 1.875$ sq. inches which is a $1\frac{7}{8}"$ bolt as seen in preceeding table.

Bolts generally have square heads and hexagonal nuts, but they may be had with either square or hexagonal heads or nuts.

JFM-3-16-10

U.S. Standard or Sellers screw threads.

The sides of the thread are inclined at an angle of 60° The tops of the threads are cut off, and the bottoms filled in so that the flat portion is $\frac{1}{8}$ of the pitch in width. The depth of the thread is .65 of the altitude

$p = .24\sqrt{d} + .625 - .175$ inch

$d_1 = d - 1.3p = d - 2p_1$

p = pitch d = diam. of bolt p_1 = real depth of thread
d_1 = diam. at bottom of thread.
n = number of threads per inch.

$n = \frac{1}{p}$ $d_1 = d - \frac{.43}{n}$

Find the pitch, number of threads per inch, diameter at root of thread, and depth of thread for a $1\frac{7}{8}$" bolt.

$p = .24\sqrt{1.875} + .625 - .175 = .204$ inch

$n = \frac{1}{.204} = 5$ (nearly) or .20" pitch

$d_1 = d - 2p_1$ or $2p_1 = d - d_1$

$\therefore p_1 = \frac{d - d_1}{2} = \frac{.26}{2} = .13$

So the pitch is $\frac{1}{5}$ or .2", there are 5 threads per inch, diam. at root of threads is 1.615" and depth of thread equals .13"

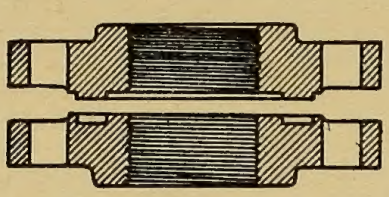
Nearest practical size hole for tapping = diam. of screw $- \frac{1.299}{\text{no. of threads per inch}}$

Take a $\frac{7}{8}$" screw with 9 threads per inch. then size of hole = $.875 - \frac{1.299}{9} = .731$ or $\frac{47}{64}$"

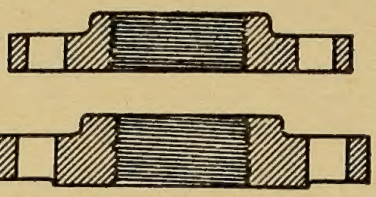
Diameter of screw in inches	Number of threads per inch.	Nearest practical size hole for tapping	Diameter at bottom of thread in inches	Area at bottom of thread in Square inches
$\frac{1}{4}$	20	$\frac{3}{16}$	.185	.0269
$\frac{5}{16}$	18	$\frac{1}{4}$	.240	.0452
$\frac{3}{8}$	16	$\frac{19}{64}$	.294	.0679
$\frac{7}{16}$	14	$\frac{23}{64}$	.345	.0935
$\frac{1}{2}$	13	$\frac{13}{32}$	.400	.1257
$\frac{9}{16}$	12	$\frac{15}{32}$	.454	1619
$\frac{5}{8}$	11	$\frac{33}{64}$	.507	.2019
$\frac{3}{4}$	10	$\frac{5}{8}$	.620	.3019
$\frac{7}{8}$	9	$\frac{47}{64}$	.731	.4197
1	8	$\frac{27}{32}$	838	.5515
$1\frac{1}{8}$	7	$\frac{61}{64}$	939	.6925
$1\frac{1}{4}$	7	$1\frac{1}{16}$	1.064	.8892
$1\frac{3}{8}$	6	$1\frac{11}{64}$	1.158	1.0532
$1\frac{1}{2}$	6	$1\frac{19}{64}$	1.283	1.2928
$1\frac{5}{8}$	$5\frac{1}{2}$	$1\frac{25}{64}$	1 389	1.5153
$1\frac{3}{4}$	5	$1\frac{1}{2}$	1.490	1.7437
$1\frac{7}{8}$	5	$1\frac{5}{8}$	1.615	2.0485
2	$4\frac{1}{2}$	$1\frac{23}{32}$	1.711	2.2993
$2\frac{1}{4}$	$4\frac{1}{2}$	$1\frac{31}{32}$	1.961	3.0203
$2\frac{1}{2}$	4	$2\frac{3}{16}$	2.175	3.7154
$2\frac{3}{4}$	4	$2\frac{7}{16}$	2.425	4.6186
3	$3\frac{1}{2}$	$2\frac{41}{64}$	2.629	5.4284
$3\frac{1}{4}$	$3\frac{1}{2}$	$2\frac{57}{64}$	2.879	6.5099
$3\frac{1}{2}$	$3\frac{1}{4}$	$3\frac{7}{64}$	3.100	7.5477
$3\frac{3}{4}$	3	$3\frac{21}{64}$	3.317	8.6414
4	3	$3\frac{37}{64}$	3.567	9.9930
$4\frac{1}{4}$	$2\frac{7}{8}$	$3\frac{13}{16}$	3.798	11.3292
$4\frac{1}{2}$	$2\frac{3}{4}$	$4\frac{1}{32}$	4.027	12.7366
$4\frac{3}{4}$	$2\frac{5}{8}$	$4\frac{17}{64}$	4.255	14.2197
5	$2\frac{1}{2}$	$4\frac{31}{64}$	4.480	15.7633
$5\frac{1}{4}$	$2\frac{1}{2}$	$4\frac{47}{64}$	4.730	17.5717
$5\frac{1}{2}$	$2\frac{3}{8}$	$4\frac{61}{64}$	4.953	19.2676
$5\frac{3}{4}$	$2\frac{3}{8}$	$5\frac{13}{64}$	5.203	21.2617
6	$2\frac{1}{4}$	$5\frac{7}{16}$	5.423	23.0978

J.F.M 12-9-09

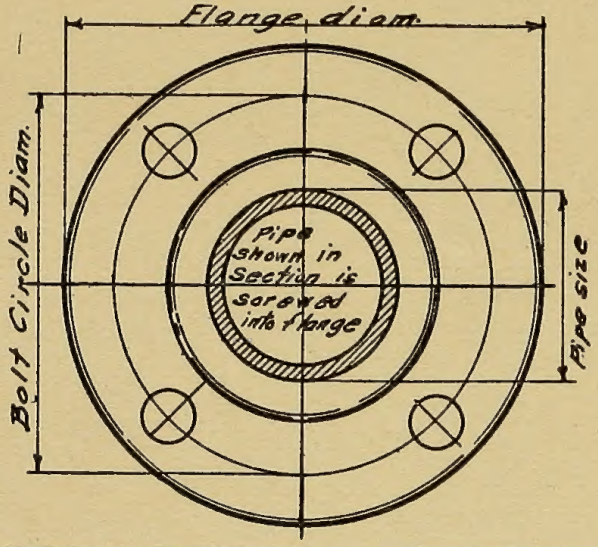
Pipe Flanges



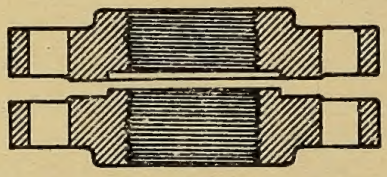
Tongued & Grooved



Plain and Heavy



Reinforced



Male and Female

Standard Flanges

Pipe size X Flange Dia.	Bolt Circle Diam.	No. of Bolts	Pressure under 80 lbs. Size of Bolts	Pressure 80 lbs. & over. Size of Bolts	Flange thickness at Hub for Iron Pipe	Flange Thickness at Edge	Width of Flange Face
2 x 6	4 3/4	4	1/2 x 2	5/8 x 2	1	5/16	2
2 1/2 x 7	5 1/2	4	1/2 x 2 1/4	5/8 x 2 1/4	1 1/8	11/16	2 1/4
3 x 7 1/2	6	4	1/2 x 2 1/2	5/8 x 2 1/2	1 1/4	3/4	2 1/4
3 1/2 x 8 1/2	7	4	1/2 x 2 1/2	5/8 x 2 1/2	1 1/4	13/16	2 1/2
4 x 9	7 1/2	4	5/8 x 2 3/4	3/4 x 2 3/4	1 3/8	13/16	2 1/2
4 1/2 x 9 1/4	7 3/4	8	5/8 x 3	3/4 x 3	1 3/8	15/16	2 3/8
5 x 10	8 1/2	8	5/8 x 3	3/4 x 3	1 1/2	15/16	2 1/2
6 x 11	9 1/2	8	5/8 x 3	3/4 x 3	1 1/2	1	2 1/2
7 x 12 1/2	10 3/4	8	5/8 x 3 1/4	3/4 x 3 1/4	1 1/2	1 1/16	2 3/4
8 x 13 1/2	11 3/4	8	5/8 x 3 1/2	3/4 x 3 1/2	1 3/4	1 1/8	2 3/4
9 x 15	13 1/4	12	5/8 x 3 1/2	3/4 x 3 1/2	1 1/4	1 1/8	3
10 x 16	14 1/4	12	3/4 x 3 5/8	7/8 x 3 5/8	2	1 3/16	3
12 x 19	17	12	3/4 x 3 3/4	7/8 x 3 3/4	2	1 1/4	3 1/2
14 x 21	18 3/4	12	7/8 x 4 1/4	1 x 4 1/4	2	1 1/8	3 1/2
15 x 22 1/2	20	16	7/8 x 4 1/4	1 x 4 1/4	2	1 1/8	3 5/8
16 x 23 1/2	21 1/4	16	7/8 x 4 1/4	1 x 4 1/4	2 1/4	1 1/16	3 3/4
18 x 25	22 3/4	16	1 x 4 3/4	1 1/8 x 4 3/4		1 1/16	3 1/2
20 x 27 1/2	25	20	1 x 4 3/4	1 1/8 x 4 3/4		1 1/8	3 3/4

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